Two Minutes to Midnight, The Agency of Hydrogen in an Art of the Anthropocene

Nicholas Laessing

UCL

Slade School of Fine Art

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Declaration

I Nick Laessing confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

This research project is an artistic investigation into the element hydrogen and its agency in the context of an art of the Anthropocene and ecological emergency. A series of installation artworks utilise hydrogen made from water as a locally produced renewable energy for artistic agency and spectator participation. Concurrently, I address the praxis and theory of interdisciplinary art practice across the areas of science, technology, and utility.

The studio practice produced a series of artworks titled *Life-Systems* that adopt the process of water-electrolysis to create hydrogen, achieved with the scientific input of the Electrochemical Innovation Laboratory at UCL. The resulting art installations test scenarios of utility within an artistic framework by finding everyday uses for hydrogen as an energy carrier and fuel. Oxygen, the waste gas of water electrolysis may be collected and repurposed.

Other artworks in the series aim towards an ecology or mutuality of interdependent technologies that engage with the water-food-energy nexus, investigating plant-food and clean water production. They aim to support one another technically whilst theoretically questioning the politics and structures of reliance upon non-sustainable resources at a time of ecological crisis.

The recently accepted view of the Anthropocene epoch as a geological event caused by human impact on earth systems, augments a shift in our relationship with our planet. My research aims to engage with and contribute to the emerging field of ontological and epistemological Anthropocene discourses by examining the roles of art, utopian narratives, and technology in this epoch. This approach also concerns the nature of interdisciplinary research, social practice, and its relations with art pedagogy. I theorise strategies to navigate the territory that connects art and science, focusing on

the paradoxical relationship of art objects and utility, aiming to contribute to knowledge and understanding in this area.

Impact Statement

The practical and theoretical outcomes of this research suggest the following potentials for impact in academic and non-academic contexts:

Renewable energy for open source and community projects:

- Repurposing pre-owned petrol and diesel cars to run on renewable hydrogen. This shows potential as a sustainable and less costly alternative to the manufacturing of new hydrogen and electric vehicles.
- This project suggests potential for small scale low-cost off grid hydrogen production and storage to provide clean safe energy for domestic use.
- Rotary hydroponic gardens produce high yields of plant food in confined spaces, offering potentials for urban food production without outside access to soil.
- *Sun Cooker* shows potential as Useful Art sculptures in public spaces, for example parks, and university campuses, for zero carbon outdoor cooking, and heating water.

Aesthetics and Pedagogy:

- The emergence of contemporary Anthropocene aesthetics offers ethical insights that may find efficacy in rethinking problematic relationships between technology and capital in a time of ecological emergency. There is potential for further research in this area.
- My research suggests that higher education faces epistemological challenges in addressing the Anthropocene and ecological crisis, requiring new pedagogical and research methodologies that embrace ecological urgencies and interdisciplinarity within and across departments.
- This project suggests that artistic practice, by adopting the criteria of Useful Art and an aesthetics of *usership* can find transformative

efficacy in addressing real world problems beyond the disciplines and conventions of a studio practice. Such practices would benefit from further theoretical and practice-based exploration.

- The tendency towards interdisciplinarity in artistic research and practice aligns with the interdisciplinary nature of Anthropocene discourses. Artistic research therefore may play a key role in connecting with and addressing the emerging issues of the Anthropocene and ecological crisis.
- As governments, corporations and institutions transition to zero carbon economies and the United Nations' Sustainable Development Goals, artistic responses that open dialogues addressing cultural transformation and adaptation in response to ecological urgencies may play a valuable role in the community.
- Reimagining the utopian narrative as a decolonised, intersectional, liberatory framework, in response to problematic eschatological interpretations of the Anthropocene, may find impact as a subject for further academic research.

Acknowledgements

I would like to thank the London Arts and Humanities Partnership (AHRC) for their financial support for this research project.

I am sincerely grateful to my supervisors, Simon Faithfull, Dr Hayley Newman, Professor Dan Brett and Dr Chiara Ambrosio, for their invaluable advice and continuous support during my study. A research project that explores disciplines of art, activism, ecocrisis and chemical engineering, could not have wished for a more inspiring, challenging, rigorous, and supportive supervisory team. I cannot thank Simon Faithful, my primary supervisor enough for his time and patience at every stage of this project, and for his considered and constructive questioning of my thinking and arguments during our conversations. I am very grateful to Dr Hayley Newman for her support and encouragement throughout this project, for her initial advice on funding which made this project possible, for introducing me to Professor Dan Brett and Dr Chiara Ambrosio, and for brilliant and inspiring conversations on art practices and texts that became extremely important to my practice and written work. I am indebted to Professor of Electrochemical Engineering, Dan Brett, for accepting an artist into the Electrochemical Innovation Laboratory for the first time. Dan's support literally opened doors, making it possible for me to work alongside EIL researchers in the department of Chemical Engineering at UCL, and to benefit from essential help and advice on testing electrolysers. Dan's scientific input and advice was extremely valuable, and I am grateful for his generosity and receptiveness to my project. Dr Chiara Ambrosio's critical input from the perspective of history and philosophy of science opened up new fascinating philosophical contexts for my research and led to truly inspiring conversations. I am grateful for her feedback on written work and support during the locked-down last stages of the project.

The Slade School of Fine Art PhD programme has been an extremely rewarding experience. I am sincerely grateful to Professor Sharon Morris, Head of the PhD Programme for this opportunity and for her kind support throughout my time as a research student. I feel extremely fortunate to have worked on research projects and public engagement workshops with brilliant colleagues - special thanks goes to Ellie Doney, Kasia Depta-Garapich, Hermione Spriggs, Eloise Fornieles, Dr Nir Segal and Dr Onya McCausland. I am grateful to Professor Joy Sleeman for her support with my PGTA teaching courses and to Slade Director of School Kieren Reed for the opportunity to co-design a teaching course with Ellie Doney. Slade Studio Manager Paul Horne and all the Slade sculpture workshop staff were a huge help with advice on fabrication and good studio practice.

I am thankful to LAHP, The Electrochemical Innovation Laboratory (EIL), Sustainable UCL and UCL Grand Challenges for project funding opportunities. EIL researchers and the UCell team, Max, James, Rhod, Jen, Josh, Lara were all incredibly kind in offering advice, helping me find my way around the lab and introducing me into UCell's public engagement activities. Public engagement projects in partnership with The Calthorpe Project were made possible with the help and support of Louise Gates, Rokiah Yaman, Katalin Patonay and Mila Campoy, for which I am enormously grateful. Production of art works was made possible through the generous financial support of Galerie PCP, Delfina Foundation, Victoria and Albert Museum, FACT, Newlyn Art Gallery and Rostock Kunsthalle.

I am thankful to Jimmy Whitmore and Jonah Kinross for the good times we had in Devon at outset of this project and grateful to Jimmy for sharing his insightful ideas, amazing fabrication skills, and workshop. Dr Charlie Dunnill of Swansea University generously offered advice on electrolysis and hydrogen safety. I thank Richard Simpson for his impeccable CAD design work and technical problem solving for *Plant Orbiter.*

A big thanks to my family and friends, for their encouragement and support throughout this time, and a very special thanks to my partner Adriana.

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Introduction

This project searches for ways to articulate and activate artistic responses to human impact on the planet, specifically in relation to utility in art. Climate science now points to humans as a dominant and problematic influence over planetary climate and geophysical processes. Artistic practice that confronts this, faces multiple issues ranging across the political, scientific and cultural. It finds itself up against powerful interests, not least a neoliberal system with global reach and military-industrial complex whose very structures appear set up in complete opposition to improving planetary conditions. [1]

> *Let me tell you a wonderful, old joke from Communist times. A guy was sent from East Germany to work in Siberia. He knew his mail would be read by censors, so he told his friends: "Let's establish a code. If a letter you get from me is written in blue ink, it is true what I say. If it is written in red ink, it is false." After a month, his friends get the first letter. Everything is in blue. It says, this letter: "Everything is wonderful here. Stores are full of good food. Movie theatres show good films from the West. Apartments are large and luxurious. The only thing you cannot buy is red ink." This is how we live. We have all the freedoms we want. But what we are missing is red ink: the language to articulate our non-freedom. The way we are taught to speak about freedom - war on terror and so on - falsifies freedom. And this is what you are doing here. You are giving all of us red ink.* [2]

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[1] While planetary harm over the past centuries may be caused by many factors such as the human short-sightedness, carelessness, or lack of a global perspective, Jacob Darwin Hamblin argues that the Cold War of the last century also saw purposeful environmental destruction through the weaponizing of planetary processes by the USSR and USA. Jacob Darwin Hamblin, *Arming Mother Nature: The Birth of Catastrophic Environmentalism* (Oxford ; New York: Oxford University Press, 2013).

[2] About Sarahana Interactive designer and co-founder of The Short Form full profile/ twitter/ www, "Slavoj Žižek Speaks at Occupy Wall Street: Transcript," *IMPOSE Magazine*, September 17, 2013, accessed March 21,

Slavoj Žižek's sense of non-freedom in his speech to the anti-austerity Occupy Wall Street demonstration can equally apply to the scarcity of cultural space allowed to climate change discourse, a discourse that would allow us to collectively confront the consequences of a legacy of harm done to the planet and long ignoring the need for change. Where is the ink that can write these changes?

This project is an effort to discover the red ink that might allow us to articulate our non-freedom; to find the space where the poetic can connect with disruptive and transformative responses in art, and its intersection with wider cultural horizons. How can art address these problems and contribute to new cultural narratives that animate alternative outcomes?

Shortly before I started this research project, a Guardian newspaper headline in August 2016, announced: 'The Anthropocene epoch: scientists declare dawn of human-influenced age.' [3] The article described that a team of geologists known as the Anthropocene Working Group (AWG) had declared to the International Geological Congress the need to recognise the profound extent of human impact on Earth. At this time, the term was also swiftly gaining traction in discourses beyond the earth sciences, across academic disciplines – including the arts and humanities - that would be affected by the scientific evidence for, to paraphrase Dipesh Chakrabarty, this newly acquired geological agency of humans. [4] In May 2019 the AWG voted in

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2021, https://imposemagazine.com/bytes/politics/slavoj-zizek-at-occupy-wall-street-transcript.

[3] "The Anthropocene Epoch: Scientists Declare Dawn of Human-Influenced Age," *The Guardian*, last modified August 29, 2016, accessed March 27, 2021, http://www.theguardian.com/environment/2016/aug/29/declare-anthropocene-epoch-experts-urge-geological-congress-human-impact-earth.

[4] Dipesh Chakrabarty, "The Climate of History: Four Theses," *Critical Inquiry* 35, no. 2 (January 2009): 197–222.

favour of designating the 1950s as the start of the Anthropocene. [5] Most significantly for humans, the Anthropocene represents a state of ecological emergency, an ongoing planetary extinction event that is threatening human populations. This leads to many questions, practical, existential and ontological. Are there workable solutions to this emergency? How are we as humans to reason with the event of our own extinction?

Such questions have led me to reflect on my own position and practice as a visual artist. The history of Western science and technology is a primary point of departure for my practice and a determining element in the media that I work with. In 2011, I was invited by the German Academic Exchange Service (DAAD) for a residency at The Potsdam Institute for Climate Impact Research (PIK), Germany, where I collaborated with mathematicians, computer scientists, and geographers engaged in future-mapping the impact of climate change. In 2015 I spent three months in Costa Rica on a German government scholarship, working with professors at EARTH University [6] specialising in renewable energy and sustainable urban farming. Alongside the everyday digest of media reports detailing extreme weather events, ecological disasters and stories of human tragedy, these experiences resulted in my practise becoming further engaged with ecological issues and

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[5] **'**The panel plans to submit a formal proposal for the new epoch by 2021 to the International Commission on Stratigraphy, which oversees the official geologic time chart' Meera Subramanian, "Anthropocene Now: Influential Panel Votes to Recognize Earth's New Epoch," *Nature* (May 21, 2019), accessed March 27, 2021, https://www.nature.com/articles/d41586-019-01641-5.

[6] EARTH University (Escuela de Agricultura de la Región Tropical Húmeda), Costa Rica, is an internationally recognised non-profit centre for research and teaching of agricultural sciences and natural resources management, with a focus on ethics, environmental and social commitment. First opened in 1990, the 33 km2 campus is based in Guacimno, Limon on farmland surrounded by secondary and primary rainforest. "EARTH University," *EARTH University*, n.d., accessed March 27, 2021, https://www.earth.ac.cr/en/.

motivated me to pursue this within the framework of practice-led academic research.

Whilst prior art theory discusses the relationship of aesthetics and utility, most recently instantiated by the Cuban artist, Tania Bruguera's criteria of Arte Útil (Useful Art), my research adds the roles of technology and the context of ecological emergency to this discussion. My methodology focusses on an art practice engaged in making hydrogen for useful purposes and develops this practice into an *ecology of hydrogen*, appropriating other technologies that thematically and technically support each other. My aim is to contextualise this practice within the Anthropocene discussion and describe its development in terms of its making (studio and laboratory work) and the exhibiting of the work within art institutions and other contexts.

On technology and ecological theory, I engage with the writings of social ecologist, Murray Bookchin and specifically his major work first published in 1982 *The Ecology of Freedom*.[7] Bookchin's lifelong devotion to the problems of human-on-human domination and hierarchy in society seems now to have renewed and essential relevance in addressing the Anthropocene. Stephen Wright's publication *Towards-a-Lexicon-of Usership*[8] has proven insightful in applying the criteria of Useful Art to its engagement with technology. Finally, I discuss the efficacy of this practice as a means of approaching the current conditions of the Anthropocene ontologically in terms of *occupying* or *being in* the Anthropocene. Here, following the aesthetic and ethical theory of Joanna Zylinska and Kathryn Yusoff, I argue that aesthetics has a significant role to play in the Anthropocene discourse and may also offer ways to approach 'the model of the technological

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[7] Murray Bookchin, The Ecology of Freedom: The Emergence and Dissolution of Hierarchy (Oakland, CA: AK Press, 2005).

[8] Stephen Wright, *Toward-a-Lexicon-of-Usership* (Eindhoven: Van Abbemuseum, 2013).

imagination' [9] - the wider problems associated with the role of technology in society.

The title of this project *Two Minutes to Midnight* [10] - *The Agency of Hydrogen in an Art of the Anthropocene* refers to The Bulletin of the Atomic Scientists' Doomsday Clock. [11] Their website states that the journal 'informs the public about threats to the survival and development of humanity from nuclear weapons, climate change, and emerging technologies.' [12] The Doomsday Clock was first displayed on its cover in 1947, evoking,

> *'...both the imagery of apocalypse (midnight) and the contemporary idiom of nuclear explosion (countdown to zero). The decision to move the minute hand is made by the Bulletin's Board of Directors in consultation with its Board of Sponsors, which includes 18 Nobel Laureates. The Clock has become a universally recognized indicator of the world's vulnerability to catastrophe…'* [13]

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[9] Murray Bookchin, The Ecology of Freedom: The Emergence and Dissolution of Hierarchy (Oakland, CA: AK Press, 2005)

[10] See fig. 52 appendix for Doomsday Clock cover illustration.

[11] In 1945 a group of Manhattan Project scientists 'who could not remain aloof to their work,' went on to establish The Bulletin of Atomic Scientists to lobby for the bomb's abolition. They offered public warnings that human activity could endanger the future of human populations, not only by military weapons development but also though industrial development. The agency continues to monitor world events gauging the threat of global catastrophe by releasing regular updates though press conferences using a graphic of a clock face. Its hand moves between quarter to midnight and midnight; the more pressing conditions become, the closer the hand moves to midnight.
"About Us," *Bulletin of the Atomic Scientists*, n.d., accessed March 27, 2021, https://thebulletin.org/about-us/.

[12] "Purpose," *Bulletin of the Atomic Scientists*, n.d., accessed March 27, 2021, https://thebulletin.org/purpose/.

[13] "About Us," Bulletin of the Atomic Scientists.

During the first year of my project, the clock moved from three to two minutes to midnight. The latest update at the time of writing sets it at one hundred seconds to midnight.

1. Research Question and Hypothesis

Primary Research Question

What are the requirements for an art practice of the Anthropocene that confronts eco-crisis?

Secondary Research Questions

- Can the making of and engagement with speculative renewable and sustainable technology - that embodies user-participation - be one such effective response?
- Can spectator interaction with such artworks made for utility, engage poetic and ethical responses towards an aesthetics of usership for ecological crisis?

Aims and Objectives

- Find artistic strategies in utility as response to the conditions of eco-crisis and the Anthropocene, exploring how the experience of usership (or the *feeling of function*), can become aesthetic experience. Through practice and theoretical work, achieve an understanding and definition of the aesthetic experience of this modality of practice. Examine the relationships between the artist, the work and the involvement of the spectator as user in this exchange. Use the above to articulate an aesthetics of utility for an art practice of the Anthropocene.
- Build water electrolysers that create hydrogen at UCL's Electrochemical Innovation Lab, taking a revisionist [14] or revivalist approach to the technology. Apply this technology in everyday use as artistic practice, find suitable contexts and partnerships.

[14] I use the term 'revisionist' here not in reference to misinforming or misrepresenting historical events (as it is also used), but to refer to reviving the potentials of redundant technologies to test their renewed usefulness for the challenges of current times.

- Reflect on the value of artistic practice across scientific disciplines, in this case producing artwork in a scientific research laboratory.
- Explore the relationships of technology, precarity and sustainability though multiple approaches, focussing on hydrogen but also making artworks that investigate plant-food and clean water production, to form ecologies of technology that support one another technically and thematically and in doing so question the politics and structures of energy dependence on fossil fuels.
- Advance my own practice by finding common ground and artistic strategies that unite the overlaps of activism, participatory art, technology, utility, and utopian experience.
- Examine how Anthropocene discourses connect fields of fine art, the humanities and science.
- Explore the agency of utopian discourses and future thinking or world building in interpretations of the Anthropocene.
- Explore how collaborative/participatory practice and the *feeling of function* as a form of utopian experience (through use of the artworks), can be a basis for tackling the complex and disturbing subject of global heating and ecocide.

2. Methodology

- Research questions were approached through the making of utility-based art installations (following the criteria of artist Tania Bruguera's Arte Útil criteria) as studio, laboratory and social practice with a focus on sustainable technologies with specific reference to renewable hydrogen systems, working with the Electrochemical Innovation Laboratory at UCL (see fig. 1).
- Establish up to date knowledge of solar and renewable hydrogen technology.
- As systems were used by participators/users, the artistic and aesthetic agency of usership or the *feeling of function* was evaluated through observation, discussion and feedback.
- Examine current context of utility in art (Arte Útil) as a response to climate crisis.
- Investigate how utopian and ethical discourses can impact on Anthropocene discourses.
- Research collaborative and participatory art practices with reference to ecocrisis.
- Establish a current overview including a historical and theoretical framework for visual art in the Anthropocene.
- Maintain a record of the work to reflect on progress as the studio practice and research develops.

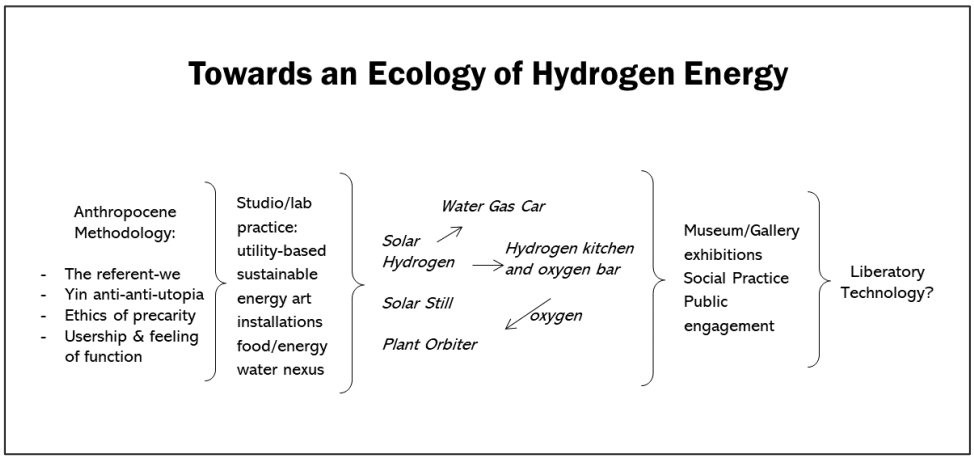

Figure 1. Research Methodology

Methods

The theoretical framework was developed alongside the practice-based methodology through the following activities:

- Studio/laboratory practice making art works for utility that follow themes outlined in methodology.
- Produce hydrogen electrolyser artworks.
- Exhibitions, workshops, collaborative partnerships, and public engagement activities. Projects and partnerships included:
    - *Water Gas Car,* exhibition, FACT Liverpool, 2016
    - *Plant Orbiter*, exhibition, PCP Galerie Paris, 2017
    - *Plant Orbiter* and *Hydrogen Kitchen* exhibition and workshops at Delfina Foundation London, 2019-2020
    - *Plant Orbiter* and hydrogen workshops at Calthorpe Project Community Garden and Cafe Kings Cross, London, 2017-2020
    - *Plant Orbiter*, exhibition and talk, Victoria and Albert Museum, London, 2020
    - *Hydrogen Kitchen* and *Water Gas Car* exhibition and workshop, Rostock Kunsthalle, 2019

    - Working with UCell public engagement team of The Electrochemical Innovation Laboratory 2016-2020
    - *Life-Systems* workshop with school students at GAMeC, Bergamo, 2019
- Reading – UCL library and online services: art theory, philosophy, hydrogen engineering, renewable energy.
- Online research – forums on DIY hydrogen, hobbyist engineering videos on YouTube.
- Site visit – to Swansea University to meet Dr Charlie Dunnill.
- Discussions with interdepartmental supervisor team, PhD colleagues.
- Conference presentations: Judgement Calls, conference, Bartlett, 2017; Petrocultures conference at University of Glasgow 2018; Art Science presentation and panel discussion Bergamo GAMeC.
- Teaching:
    - Designed and taught course *Navigating the Anthropocene*, a 5-seminar course for Fine Art BA1 Slade School of Art, over 3 years
    - Codesigned and taught *Ecologies of Art and Making* with PhD colleague Ellie Doney, a 5-day interdisciplinary foundation pilot for Slade School of Art.
    - Workshops and teaching in art schools and museums in UK, Germany, and Italy.
- Photographic and video documentation of artwork.

3. Research Context

3.1 Climate, Capital and Culture

Figure 2. Climate emergency demonstration at Tate Modern, October 2018, photo Nick Laessing

Industrial processes are transforming the planet to the extent that human populations are now endangered. [15] The main threat to humans is primarily a result of the burning of fossil fuels [16] that releases additional carbon dioxide

[15] '…climate change will change everything about our world. Major cities will very likely drown, ancient cultures will be swallowed by seas, and there is a very high chance that our children will spend a great deal of their lives fleeing and recovering from vicious storms and extreme droughts.' Naomi Klein, *This Changes Everything: Capitalism vs. the Climate*, 2015, 4.

[16] '87 percent of all human-produced carbon dioxide emissions come from the burning of fossil fuels like coal, natural gas and oil. The remainder results from the clearing of forests and other land use changes (9%), as well as some industrial processes such as cement manufacturing (4%).' "Main Sources of Carbon Dioxide Emissions | CO2 Human Emissions," accessed March 22, 2021, https://www.che-project.eu/news/main-sources-carbon-dioxide-emissions.

into the atmosphere. [17] The scale of these emissions is far smaller than that generated and absorbed by earth processes, and yet this surplus of carbon dioxide cannot be re-absorbed by the earth's systems (see fig. 3). Because this gas is highly effective at trapping heat from the sun that would otherwise radiate back out into space, the planet continues to warm beyond its own ability to self-regulate.

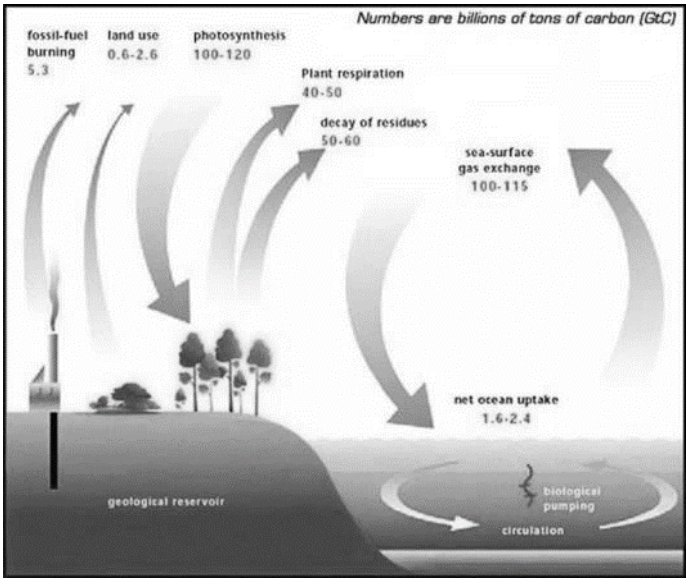

Figure 3. The Global Carbon Cycle. Numbers represent flux of carbon dioxide in gigatons.
"The Global Carbon Cycle," *SMAP*, accessed May 4, 2021, https://smap.jpl.nasa.gov/resources/35/the-global-carbon-cycle.

The consequences of this greenhouse effect are to be found in planetary changes to weather patterns, increasing cases of extreme weather events and natural disasters such as typhoons, hurricanes, forest fires, flooding, desertification, ocean acidification, and sea level rise due to glacial melting

[17] But not exclusively; other issues such as vehicle pollution, factory pollution, destruction of habitats by industrial processes and the fossil fuel industry, mining, refining, processing, do not yet directly threaten us but would show up as Anthropocene markers in future geology as would layers of plastic and concrete.

in Arctic and Antarctic regions. [18] In hard hit areas this has led to species extinction, food scarcity and human migration as well as conflict and civil war. [19] Models used in the future mapping of climate breakdown are continuously being revised as new data emerges to reveal that past predictions were underestimated. Nomenclature such as the arctic death spiral (see fig. 4), is now being used by scientists working in polar regions in reference to ice melt, where melting permafrost (the layer of ground at or below zero °C for two or more years), [20] is causing the escape of methane gas which was previously trapped in frozen ground. [21] Glacial ice cover of the ocean reflects solar radiation back into the atmosphere (known as the albedo effect). However, as glaciers melt and the surface area of sea-ice decreases to reveal ocean, seawater then absorbs greater amounts of solar radiation, which further contributes to planetary warming. In his book, *Farewell to Ice*, Peter

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[18] 'Over the course of the 1970s, there were 660 reported disasters around the world, including droughts, floods, extreme temperature events, wildfires, and storms. In the 2000s, there were 3,322—a fivefold boost. That is a staggering increase in just over thirty years, and clearly global warming cannot be said to have "caused" all of it. But the climate signal is also clear.' Naomi Klein, *This Changes Everything: Capitalism vs. the Climate*, 2015, 107

[19] According to Klein the Arab Spring was instigated by the county's droughts and crop shortages. Naomi Klein, *This Changes Everything: Capitalism vs. the Climate*, 2015, 9.

[20] Hugues Lantuit, "What Is Permafrost?," *International Permafrost Association*, last modified February 15, 2009, accessed March 22, 2021, https://ipa.arcticportal.org/publications/occasional-publications/what-is-permafrost.

[21] This occurs both on land and on the seabed. Recent reports discuss rates of melting underwater permafrost is now occurring ten times faster than previously predicted that could lead to 'massive emissions of methane bubbles.'
"Underwater Permafrost on the Arctic Shelf Melting Faster than Expected," accessed March 27, 2021, https://arctic.ru/climate/20170809/655109.html.
Peter Wadhams also discusses the UK's corroboration of these observations. P. Wadhams, *A Farewell to Ice: A Report from the Arctic* (New York, NY: Oxford University Press, 2017).

Wadhams, professor of Ocean Physics at the University of Cambridge, argues that these two previously unexpected events may accelerate runaway planetary warming far beyond predictions made by the pre-existing data used in climate modelling.

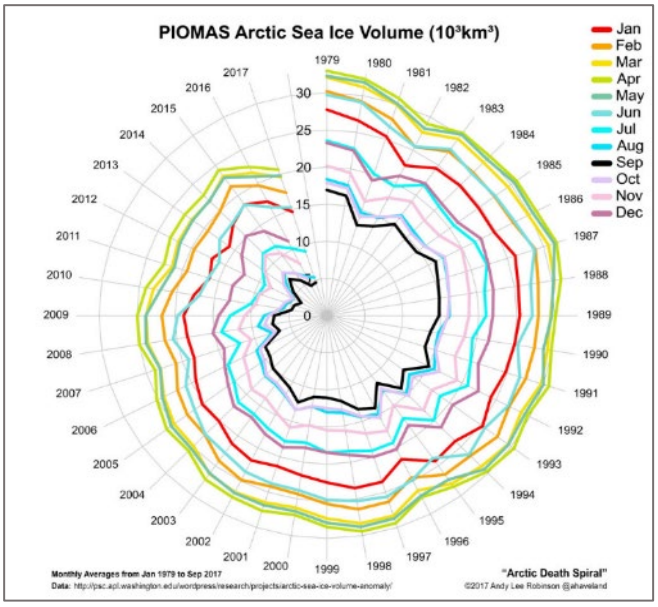

Figure 4. The 'Arctic death spiral'. Ice volume for each month of each year since 1979 on a polar plot so that a declining ice volume is seen as a spiral moving towards the centre of the graph. Monthly averages from January 1979 - January 2014. 2017 Version. Data source via the Polar Science Center (University of Washington). Data visualisation by Andy Lee Robinson.
"Datei:Arctic-death-spiral.png," *Wikipedia*, n.d., accessed March 27, 2021, https://de.wikipedia.org/wiki/Datei:Arctic-death-spiral.png

Worldwide recognition at government level for the need to reduce carbon dioxide emissions to limit average global temperatures has been in evidence since the first meeting of governments in 1988 at the World Conference on

the Changing of the Atmosphere in Toronto. [22] This led to the founding of the IPCC (Intergovernmental Panel on Climate Change in 1998), and the 1992 United Nations Rio Earth Summit which set out the first agreement among nations to stabilise greenhouse gas concentrations. [23]

In 2015 the COP21 Paris Agreement was reached at the United Nations Framework Convention on Climate Change (UNFCCC) in Paris by 194 member nations. This aims to hold the increase in average global temperatures to 2°C above pre-industrial levels and preferably to a 1.5°C level. One of the three principle aims of the agreement is to establish 'financial flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development.' [24] This ambiguously worded

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[22] Naomi Klein, This Changes Everything: Capitalism vs. the Climate, 2015, 55.

[23] United Nations Framework Convention on Climate Change. The ultimate objective of the Convention is to stabilize greenhouse gas concentrations 'at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system.' It states that 'such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.' "Untitled," accessed March 27, 2021, https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change. Unfccc.int. 2018.

[24] The aim of the convention is described in Article 2, 'enhancing the implementation' of the UNFCCC through
'(a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial [levels] and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change
(b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production
(c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.'

statement recognises the responsibility of finance but does not go further to indicate how such ‘pathways’ may be established.

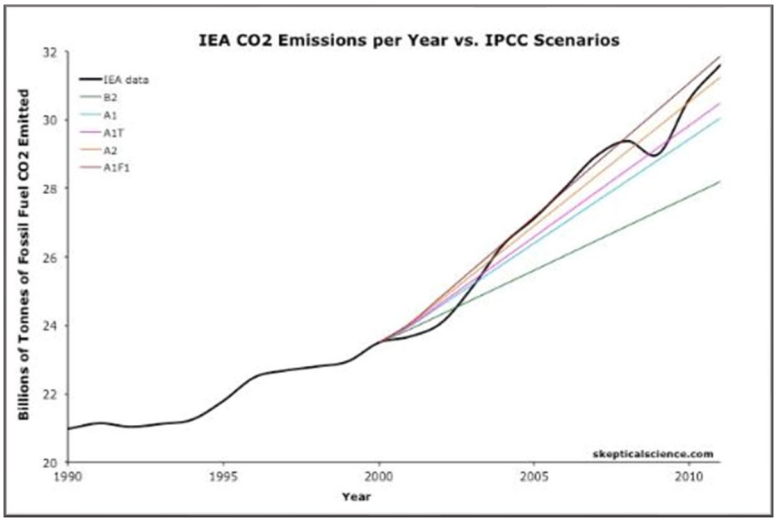

Figure 5. Observed CO2 Emissions vs IPCC Scenarios Dana Nuccitelli, English: Shows in Graphic Form the Projected Increase in Carbon Dioxide (CO2) Emissions from Fossil Fuels in Five of the Emissions Scenarios Used by the Intergovernmental Panel on Climate Change (IPCC), Compared to the International Energy Agency’s (IEA’s) Actual Observational CO2 Emissions Data from Fossil Fuel Consumption., June 3, 2011, http://www.skepticalscience.com/graphics.php Skeptical Science, accessed March 22, 2021, https://commons.wikimedia.org/wiki/File:Global_Warming_Observed_CO2_Emissions_from_fossil_fuel_burning_vs_IPCC_scenarios.jpg

Fossil fuel extraction such as coal mining, fracking and oil drilling cause direct environmental damage instantiated by oil spills and water poisoning on a local scale, damaging ecosystems and harming wildlife and human life, but when seen from a planetary perspective these dramatic, newsworthy events pale into insignificance when compared to the global reengineering of the planet that is being enacted by the freeing of trapped carbon in fossil fuels

“United Nations 2015 Paris Agreement,” 2021. https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf.

now being released as the gas carbon dioxide. Governments, under pressure from a culture of powerful corporate lobbying appear virtually powerless to sufficiently protect the interests of their populations and habitats by passing and enforcing necessary regulatory legislation.

As the first climate agreements were negotiated in the 1990s between governments to reduce carbon dioxide emissions, [25] during the same decade many of those governments signed up for free trade agreements, initiating a new era of accelerated growth in global trade, led by international manufacturing and transportation networks. [26] The result was a dramatic increase in greenhouse gases (see fig 5). This embodies the problematic relationship of financial and climate interests, that forms the basis of Naomi Klein's 2015 book *This Changes Everything*. [27] There appeared to be a distinct lack of recognition of the need for agreements that would consider the relationship of climate and finance as inseparable. Tellingly, the only period where C02 emissions decreased for a brief period was during the 2008 world recession (see fig. 5). Many climate scientists regard the Paris agreement as not binding enough to be realistically effective and are

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[25] "UNFCCC -- 25 Years of Effort and Achievement," accessed March 27, 2021, https://unfccc.int/timeline/.

[26] This coincided with the opening up of new shipping routes due to Arctic ice melt:
'Last September the Danish Venta Maersk became the first container ship to complete the Northern Sea Route, traveling from East Asia to northern Europe. The journey was 10 days shorter than the southern route through the Suez Canal, but it required the help of a Russian icebreaker. Arctic shipping routes aren't expected to be cost-effective until the region is more ice free.'
"The Melting Arctic Is Now Open for Business," *National Geographic*, accessed March 27, 2021, https://www.nationalgeographic.com/environment/graphics/map-shows-how-ships-navigate-melting-arctic-feature.

[27] Naomi Klein, This Changes Everything: Capitalism vs. the Climate, 2015, 81

concerned that the targets lack specificity. [28] There is not yet a globally agreed timeline for achieving the carbon dioxide 2°C target and pledges of aid to developing countries that will be hardest hit by climate change have been minimal. The upcoming 2021 COP26 in Glasgow aims to review progress towards the Paris Agreement, 'bridging the gap between pledges and delivery.' [29] Negotiations will aim to pledge further emission cuts by 2030, publish plans to achieve net zero emissions by 2050, and fulfil funding commitments to Global South nations. [30]

In *This Changes Everything*, Naomi Klein provides a rigorous account of the failure of late capitalism to accept responsibility for climate crisis. She argues that industrial emissions on a global scale cannot be reduced without implementing changes in the capitalist system itself and makes a convincing case for the urgent need both to protect existing spaces outside capitalism but also to find alternatives to neoliberal capitalist orthodoxies. She argues that the protection of freedoms allows individuals to make informed ethical decisions. For example, in the US, enforced precarity (a minimum wage that undercuts a living wage and poor standards of social welfare), affects individuals forced to take jobs in morally and ethically questionable sectors like the fracking industry. These short-term contract sectors in remote regions

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[28] According to Michael Le Page and Catherine Brahic of the New Scientist, 'The strongest criticism has come from climate scientist James Hansen at Columbia University: 'It's just worthless words. There is no action, just promises. As long as fossil fuels appear to be the cheapest fuels out there, they will be continued to be burned.' Michael Le Page, "What Is the Paris Climate Agreement?," *New Scientist*, accessed March 23, 2021, https://www.newscientist.com/article/dn28663-what-is-the-paris-climate-agreement/.

[29] "Road to Glasgow: Key Summit Asks," *Energy & Climate Intelligence Unit*, accessed March 30, 2021, https://www.eciu.net/analysis/briefings/international-perspectives/road-to-glasgow-key-summit-asks.

[30] "Road to Glasgow: Key Summit Asks," *Energy & Climate Intelligence Unit*.

also do not offer opportunities for communities to grow. People earn their money and move on, while often long-term inhabitants and indigenous communities in these locations are forced out due to impacts on their quality of life and environment.

Klein's investigations into the successes of community organised activism against fossil fuel industries in various parts of the world demonstrate the value and achievements of cultural and collective resistance. She has witnessed resistance movements defeating Big Oil projects and unwelcome government initiatives. Klein stresses the importance of community, culture and solidarity as the foundations of resistance and change. She argues that successful models for fighting Big Oil and industry exist in resistance movements of the past such as the civil rights movement and the legal campaigns against Big Tobacco.

Throughout the course of my research, mainstream awareness of and responses to climate emergency have increased noticeably. From a European perspective, this is perhaps due to increasing experiential encounters with extreme weather events (record temperatures, forest fires, and the flooding of homes), media coverage of global climate related environmental catastrophes, climate migration, and the growing awareness of scientific data. In February 2019 it was strange to see crowds of London commuters wearing T-shirts as temperatures unexpectedly moved above 20 degrees. According to climate scientists, this 'weirding of the weather' was a one in two-hundred-year event; probability close to zero. [31] Extremes of heat are being recorded ten times more often than extremes of cold – in Europe Summer heatwaves

[31] "UK Weather: February Temperature Jump Was Incredible, Says Climate Expert," *The Guardian*, last modified March 2, 2019, accessed March 30, 2021, http://www.theguardian.com/uk-news/2019/mar/02/uk-temperature-jump-february-incredible-climate-weather-carbon.

are also now thirty times more likely. [32] The Guardian newspaper announced in May 2019 that it had revised its language to describe these conditions: 'climate breakdown' has replaced 'climate change'; 'global heating' replacing 'global warming' [33]. In September 2018 the BBC notified journalists that they no longer need present counter arguments to the human causes of global heating in its programme making. [34]

Two climate movements have recently emerged in Europe that have captured international attention: Extinction Rebellion or XR (cofounded by Roger Hallam and Gail Bradbrook in 2018), in the UK, and in the same year Fridays for Future was founded by the Swedish activist Greta Thunberg. Her speech beginning with the words, 'Our house is on fire', at the World Economic Forum in 2019 found international recognition and has galvanised an international youth climate protest movement.

Far less visible in comparison is the extensive and ongoing history of activism in the Global South; individual and community resistance to ecological destruction such as land grabs, mining, deforestation and fossil fuel extraction by powerful multinational corporations. Activists working on the front lines of ecological disasters are exposed to multiple risks such as pollution and toxicity that makes soil and drinking water unsafe, and harmful levels of air pollution. In these regions resistance can lead to violent retaliation,

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[32] UK Weather: February Temperature Jump Was Incredible, Says Climate Expert," *The Guardian*.

[33] "Why the Guardian Is Changing the Language It Uses about the Environment," *The Guardian*, last modified May 17, 2019, accessed March 30, 2021, http://www.theguardian.com/environment/2019/may/17/why-the-guardian-is-changing-the-language-it-uses-about-the-environment.

[34] "No More BBC Platform for Climate Change Deniers? It'd Be about Time | Richard Black," *The Guardian*, last modified September 10, 2018, accessed March 30, 2021, http://www.theguardian.com/commentisfree/2018/sep/10/bbc-climate-change-deniers.

criminalisation, and death. [35] Prominent environmental activists in the Global South include Honduran activist Berta Cáceres founder of The Council of Popular and Indigenous Organizations of Honduras who was assassinated following her successful campaign to prevent the Agua Zarca Dam; the Indian academic and environmentalist Vandana Shiva known for her work with farming and seed freedom; Nobel prize winner and social-environmental activist, Wangarĩ Muta Maathai (1940-201) launched the Greenbelt Movement, a community tree planting organisation in Kenya.

In 2019 The Wretched of the Earth climate coalition, based in the UK and representing a diversity of Global South activist organisations published an open letter to XR announcing their alignment with the organisation but also calling for greater acknowledgement and awareness of the intrinsic relationships between imperialism, colonialism and the ecological, stating '[t]he climate movement will be decolonial or it will be nothing…Our communities have been on fire for a long time and these flames are fanned by our exclusion and silencing.' [36]

These networks actively seek solidarity with Global North climate activism, but at the same time this letter clearly marks a rift between strategies founded on white privilege that do not offer compatibility or inclusivity in a racialised society where for example, strategies of purposefully seeking arrests at demonstrations carry unequal measures of risk in relation to ethnicity. The letter recognises the wider systemic and historical colonial context of climate crisis:

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[35] "Nine Activists Defending the Earth from Violent Assault," *The Guardian*, July 21, 2018, sec. Environment, accessed March 27, 2021, http://www.theguardian.com/environment/2018/jul/21/defending-earth-violence-murder-activists-land-corruption.

[36] "An Open Letter to Extinction Rebellion," *Journal of Global Faultlines* 6, no. 1 (2019): 109.

> *In order to envision a future in which we will all be liberated from the root causes of the climate crisis – capitalism, extractivism, racism, sexism, classism, ableism and other systems of oppression – the climate movement must reflect the complex realities of everyone's lives in their narrative.* [37]

As the Wretched of the Earth coalition points out, inequity or injustice becomes the essential and chronic condition of climate crisis. Its dismantling may be the greatest challenge on the path towards confronting climate crisis. Where does such a project begin? Perhaps to paraphrase Roxane Gay, white privilege of the Global North can start by taking on the problems born of oppression wholeheartedly as their own. [38]

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[37] "An Open Letter," Journal of Global Faultlines.

[38] '...everyone, on all sides, has to try to understand and accept complication, fight against dichotomies, essentialism. We have to think with nuance...'
"Roxane Gay: 'Public Discourse Rarely Allows for Nuance. And See Where That's Gotten Us,'" *The Guardian*, last modified December 27, 2018, accessed March 27, 2021, http://www.theguardian.com/books/2018/dec/27/roxane-gay-writer-interview-literary-fiction-reading-diversely.

3.2 The Anthropocene

We must now collectively undertake a rewriting of knowledge as we know it. This is a rewriting in which, inter alia, I want the West to recognize the dimensions of what it has brought into the world—this with respect to, inter alia, our now purely naturalized modes or genres of humanness. You see? Because the West did change the world, totally. [39]

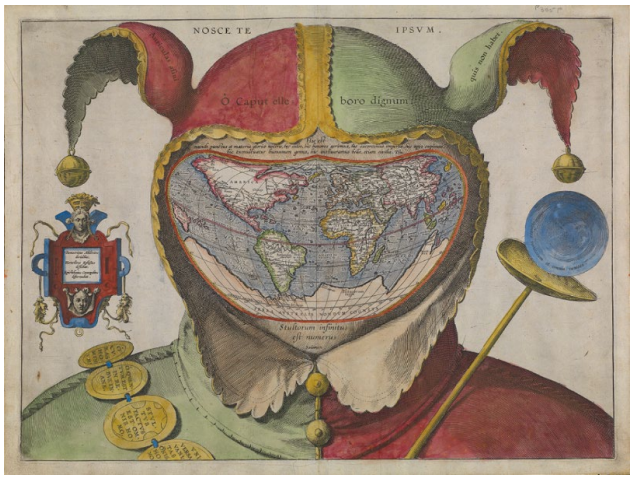

Figure 6. Fool's Cap World Map based on based on an earlier woodcut map by Jean de Gourmant. 'De Gourmant's fool's head was regarded as a warning against earthly fantasies of power, pride and folly. Tattooed on the fool's forehead is a proclamation of how absurd it is for men to fight over the earth with sword and flame. De Gourmont calls the earth the "world point." This was a revolutionary term at a time when there was no telephone, no Internet, when no one spoke of a "global village" [He] was thus one of the first to realize that the world is truly small, rather than the infinite space it seemed to conquerors at the time.'
Christian Schwägerl, *The Anthropocene: The Human Era and How It Shapes Our Planet* (Santa Fe, NM: Synergetic Press, 2014), 1089-1090.

[39]McKittrick, Katherine. *Sylvia Wynter: on Being Human as Praxis*. Durham: Duke University Press, 2015, 18.

The term the Anthropocene became popularized in 2000 by Dutch atmospheric chemist Paul J. Crutzen and limnologist Eugene F. Stoermer. [40] It was first raised by Crutzen in reference to the dominance of human impact over Earth systems during a United Nations conference he attended in Mexico [41] and has since become widely accepted as referring to the current global geological event that follows the 11,700 year epoch of the Holocene. The AWG, a scientific study group (the Anthropocene Working Group of the Subcommission on Quaternary Stratigraphy) has since determined that the term holds validity for the scientific community and in 2016 voted to use the term for our present epoch, launching a geological survey to search for evidence in sediment layers. Indicators include vastly increased levels of phosphorous and nitrogen in soil, micro-plastics, concrete, domestic chicken bones, atomic bomb testing, and previously airborne particulates such as black carbon from fossil fuel burning. Though not found in earth sediment, currently the most evident and quantifiable signal of human-caused irreversible change is that of atmospheric carbon dioxide emissions that cause global heating.

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[40] 'In 2000, Crutzen contacted Stoermer, as is proper when two scientists have arrived at the same conclusions independently of one another. He suggested that they publish the Anthropocene idea together. Stoermer agreed, later saying: "I began using the word 'Anthropocene' in the 1980s, but I never formalized it until Paul contacted me."' Christian Schwägerl, *The Anthropocene: The Human Era and How It Shapes Our Planet* (Santa Fe, NM: Synergetic Press, 2014), Kindle Locations 1053-1056.

[41] 'The chairman mentioned the Holocene again and again as our current geological epoch. After hearing that term many times, I lost my temper, interrupted the speaker and remarked that we are no longer in the Holocene. I said that we were already in the Anthropocene. My remark had a major impact on the audience. First there was silence, then people started to discuss this.'
Christian Schwägerl, *The Anthropocene*, Kindle Locations 254-256.

Whose Anthropocene?

Scientific consensus points to the 1950s as marking the beginning of the Anthropocene era, [42] when carbon dioxide levels rose steeply alongside the acceleration of industrial processes (fig. 7). The AWG survey currently proposes the years 1945-1963 as the current Anthropocene marker - a result of atom bomb detonations which released radioactive

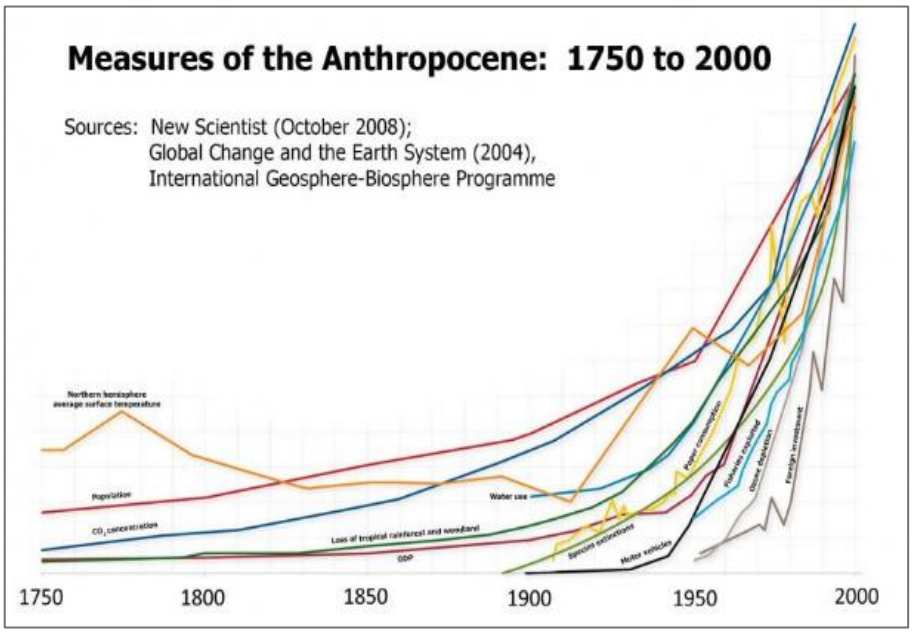

Figure 7. The sharp upward spike in all the trends displayed on this graph show how human activity has increased since the Great Acceleration. Measures of the Anthropocene: 1750 to 2000. Indicators: northern hemisphere average surface temperature, population, CO2 concentration, loss of tropical rainforest and woodland, motor vehicles, water use, foreign investment, fisheries exploited, paper consumption, species extinctions, ozone depletion. "The Age of Humans: Evolutionary Perspectives on the Anthropocene | The Smithsonian Institution's Human Origins Program," accessed May 4, 2021, https://humanorigins.si.edu/research/age-humans-evolutionary-perspectives-anthropocene.

[42] "The Anthropocene Epoch: Scientists Declare Dawn of Human-Influenced Age," *The Guardian*, last modified August 29, 2016, accessed March 27, 2021, http://www.theguardian.com/environment/2016/aug/29/declare-anthropocene-epoch-experts-urge-geological-congress-human-impact-earth.

debris known as radionuclides into sediments and glacial ice (the first H-bomb test occurred in 1952 and in 1963 the Limited Nuclear Test Ban Treaty prohibited further above ground testing [43]).

> *The Anthropocene is only partly what we do; the other part is what happens to us as a consequence of what we do... [it] is more than the sum of the parts of environmental havoc. It can be the arena in which humanity decides to wisely integrate into the planet's workings, enriching itself by its actions as a result.* [44]

In 2015 UCL academics Mark Maslin and Simon Lewis published research that concurred with the 'golden spike' of The Atomic Age. They also hypothesised a second Anthropocene marker, the first centuries of accelerated global trade and movement of humans - the 15th and 16th centuries. From a geological perspective, analysis of Antarctic ice cores shows a significant decrease in CO2 levels for around 1610, a period when Europeans colonised North America leading to native American farming land returning to its natural state and new growth absorbed more atmospheric C02. [45] The

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[43] On Nov. 1, 1952, the United States conducted its first nuclear test of a fusion device, or "hydrogen bomb," at Eniwetok in the Marshall Islands. The Learning Network, "Nov. 1, 1952 | First Hydrogen Bomb Test," *The Learning Network*, November 1, 2011, accessed March 27, 2021, https://learning.blogs.nytimes.com/2011/11/01/nov-1-1952-first-hydrogen-bomb-test/.

[44] Christian Schwägerl, *The Anthropocene: The Human Era and How It Shapes Our Planet* (Santa Fe, NM: Synergetic Press, 2014), Kindle Locations 2771-2772.

[45] 'US census data suggest the Native American population may have been as low as 250,000 people by 1900 from a pre-Columbus level of 5 million, a 95% decline.' UCL, "Opinion: Why the Anthropocene Began with European Colonisation and Mass Slavery," *UCL News*, last modified June 25, 2020, accessed March 27, 2021, https://www.ucl.ac.uk/news/2020/jun/opinion-why-anthropocene-began-european-colonisation-and-mass-slavery.

researchers followed this with a related paper in Nature, in June 2020 - in the midst of Black Lives Matter protests across the USA and UK, and the Covid-19 pandemic - which begins:

> *The toppling of statues at Black Lives Matter protests has powerfully articulated that the roots of modern racism lie in European colonisation and slavery. Racism will be more forcefully opposed once we acknowledge this history and learn from it. Geographers and geologists can help contribute to this new understanding of our past, by defining the new human-dominated period of Earth's history as beginning with European colonialism.* [46]

They cite the professor of geography and transdisciplinary researcher Kathryn Yusoff, who in 2018 published *A Billion Black Anthropocenes or None* which addresses the Anthropocene from the perspective of feminist black theory, geology and aesthetics. Yusoff and decolonial academics might reply that the origins of modern racism have in fact been recognised to lie in European colonialism long before these recent protests.[47] For Yusoff, 'The Anthropocene began with the annihilation of the Colonial Other.'[48] She interrogates the 1610 Anthropocene 'golden spike' as human experience, asking 'how does this rupture of bodies, flesh, and worlds become buried in the notion of exchange and contact?' She adds:

> *the fungibility of Blackness and geologic resources (as land, minerals, and ores) is coeval, predicated*

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[46] UCL, "Opinion: Why the Anthropocene Began with European Colonisation and Mass Slavery," *UCL News*, last modified June 25, 2020, accessed March 27, 2021, https://www.ucl.ac.uk/news/2020/jun/opinion-why-anthropocene-began-european-colonisation-and-mass-slavery.

[47] '…imperialism and ongoing (settler) colonialisms have been ending worlds for as long as they have been in existence.' Kathryn Yusoff, A billion black Anthropocenes or none, 2018, 12.

[48] Kathryn Yusoff, A billion black Anthropocenes, 42.

> *on the ability of the colonizer to both describe and operationalize world-space as a global entity.* [49]

Maslin and Lewis state that Yusoff, 'makes it very clear that predominantly white geologists and geographers need to acknowledge that Europeans decimated indigenous and minority populations whenever so-called progress occurred.' [50] The events of 2020 and Yusoff's work seem to have convinced Maslin and Lewis to fully address the Anthropocene as a colonial event within their own field of research. This acknowledgement of Yusoff's thesis may be an important moment in reflexivity of the Anthropocene from the perspective of white Western academic (in this case also male) geology and geography.

Donna Haraway argues for many, and Yusoff, *A Billion Black Anthropocenes or None,* but Maslin and Lewis, suggest two distinct Anthropocenes. Firstly, the geological evidence of the 1950s tells of extraordinary scientific and technological progress in military and industrial contexts: The Atomic Age and the Great Acceleration combined to present a valorised, sublime Anthropocene, where Western human advances result in what might become its own 'heroic' downfall. [51] In this Anthropocene so far untested

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[49] Kathryn Yusoff, A billion black Anthropocenes, 42.

[50] UCL, "Opinion: Why the Anthropocene Began with European Colonisation and Mass Slavery," *UCL News*, last modified June 25, 2020, accessed March 27, 2021, https://www.ucl.ac.uk/news/2020/jun/opinion-why-anthropocene-began-european-colonisation-and-mass-slavery.

[51] This is further addressed in the following section on Utility and Utopia in Art. Science fiction writer Ursula K Le Guin describes this as Western utopia: 'from Plato on, utopia has been the big yang motorcycle trip. Bright, dry, clear, strong, firm, active, aggressive, lineal, progressive, creative, expanding, advancing, and hot.'
Ursula K Le Guin, "A Non-Euclidean View of California as a Cold Place to Be," *The Anarchist Press* (1982): 11, https://cpb-us-e1.wpmucdn.com/sites.ucsc.edu/dist/9/20/files/2019/07/1989a_Le-Guin_non-Euclidean-view-California.pdf.

technologies such as solar geoengineering [52] still might offer a last-ditch techno-fix to cool the planet. The second Anthropocene of 1610 is that of ongoing trajectories of human-on-human and human-on-nonhuman violence: accumulation through dispossession, genocide, ecocide, extraction, domination and injustice. These two Anthropocenes are wholly inseparable and yet all too unrecognisable to each other. [53]

The study of human histories of oppression and domination over other humans and over planetary systems has led to an emergence of discourses that connect the scientific, decolonial, social, political, environmental, and cultural fields. Whilst being a global phenomenon of a geophysical nature, affecting human populations, weather, geography, geology, biology, species extinction and adaptation, the Anthropocene has catalysed anthropocentric reflection, becoming amalgamated into specialisms of knowledge and philosophy, forcing reconsideration of pre-existing paradigms regarding how we understand ourselves, our surroundings, and time.

The Anthropocene-Earth model can be understood as an interdependent, complex network of human and nonhuman support systems within the bio- and geo-sphere, where the accumulative and compound effects of apparent small-scale local disruptions primarily caused by humans can cause devastating long term (and in many cases irreversible) 'massively

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[52] For an introduction to geoengineering see: By Erik Conway Laboratory NASA Jet Propulsion, "Just 5 Questions: Hacking the Planet," *Climate Change: Vital Signs of the Planet*, accessed March 28, 2021, https://climate.nasa.gov/news/1066/just-5-questions-hacking-the-planet.

[53] See also Sylvia Wynter: 'The white utopia was black inferno'
Sylvia Wynter, "Unsettling the Coloniality of Being/Power/Truth/Freedom: Towards the Human, After Man, Its Overrepresentation--An Argument," *CR: The New Centennial Review* 3, no. 3 (2003): 257–337.

distributed', global results.[54] Such impacts across the world are now so prevalent that they are being reported almost daily in news media. In everyday life, we are now increasingly living with the consequences of at least a century of this accumulation. Technology can instantly connect an individual remotely to almost anywhere in the world in real time; the ozone over Antarctica was depleted due to industrial fluorocarbon emissions from distant locations;[55] radioactive traces from the Fukushima nuclear plant is found in fish on the west coast of North America. The world has never appeared smaller and more connected. Geologists in the future studying this period will uncover the human footprint at every turn.

> *Thus, there is no "environment" any longer that surrounds our civilization. We are living in an "invironment," a new nature that is strongly shaped by human needs and that has no outside. In this new reality, nature becomes culture and culture becomes nature; technology becomes the environment and the environ-ment is turning into the technosphere; the economy will become ecology and ecology will become economy.*[56]

Adaptation

In law and ethics, one such example of the breakdown of the local-global dichotomy is the concept of the tragedy of the commons in relation to climate

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[54] Timothy Morton, *Hyperobjects: Philosophy and Ecology after the End of the World*, Posthumanities 27 (Minneapolis: University of Minnesota Press, 2013).

[55] CFCs are attracted to ice crystals in the atmosphere.
Christian Schwägerl, *The Anthropocene: The Human Era and How It Shapes Our Planet* (Santa Fe, NM: Synergetic Press, 2014), Kindle Locations 210-211.

[56] Christian Schwägerl, *The Anthropocene,* Kindle Locations 1804-1807.

change. [57] Global South nations continue to suffer the consequences of environmental problems caused by post industrial nations. [58] How should they be compensated? As sea levels rise and populations lose their homes who will rehouse these communities? The podcast series *Power in the Pandemic* presents interviews with academics, development workers, and activists responding to their experiences of the combined effects of Climate change and the Covid-19 pandemic in the Global South. Activist Betty Barkha from Fiji, describes climate change as a threat multiplier.

> *"How can a lock down be compatible with losing your home due to flooding. How can physical distancing be compatible with being in crammed evacuation centres? How do you handle a double crisis? The patriarchy is not on lockdown"* [59]

In 2015 US media reported that Florida state employers were forbidden to use the term climate change. [60] Lacking adequate coastal flood defences Miami is now experiencing seawater flooding streets and buildings while government

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[57] "Tragedy of the Commons," *Encyclopedia Britannica*, accessed March 29, 2021, https://www.britannica.com/science/tragedy-of-the-commons.

[58] Yusoff describes this as the 'racialised impacts of climate change'. She later adds 'Nicholas Robbins (2011) argues that there was a double genocide: the initial
invasion of the New World and its impact on indigenous people, then a second wave of genocide through silver mining and the afterlives of mercury
pollution into the soil, ecologies, and bodies of local communities.'
Kathryn Yusoff, A billion black Anthropocenes or none, 2018, 57.

[59] Oxfam, "Power in the Pandemic Podcast," *Oxfam Views & Voices*, accessed March 28, 2021, https://views-voices.oxfam.org.uk/the-oxfam-podcast/. Betty Barkha.

[60] "Florida Banned State Workers from Using Term 'climate Change' – Report," *The Guardian*, last modified March 8, 2015, accessed March 28, 2021, http://www.theguardian.com/us-news/2015/mar/08/florida-banned-terms-climate-change-global-warming.

legislation is still to catch up with the problem of liability. This has left property law unwilling to deal with the reality of the consequences of changing weather patterns that bring more frequent hurricanes, heavy rainfall and sea surges. Gradually, new progressive relationships are being forged between different scientific fields and industry, as physicists, geographers, and weather scientists attempt to assimilate data for predicting future patterns and events and their consequences for human populations. While few nations have developed national policies that confront these issues, Germany's Energiewende (energy transition), a policy initiated in 2010 stands out as a long-term investment project to transition from fossil fuel dependence in favour of alternative technologies such as photovoltaic and wind turbine power. Similarly, China describes the next phase of its development as the ecological civilization (following its agricultural and then industrial civilizations).[61] In 2014 as part of a newly adapted constitution recognizing the need for changes in economic, industrial and agricultural policy, laws were introduced such as allowing independent organisations to sue polluting Chinese companies.

[61] "'My Job Is to Clean up the Environment. China Really Wants to Do That,'" *The Guardian*, last modified September 10, 2017, accessed March 28, 2021, http://www.theguardian.com/environment/2017/sep/10/my-job-is-to-clean-up-the-environment-china-really-wants-to-do-that.

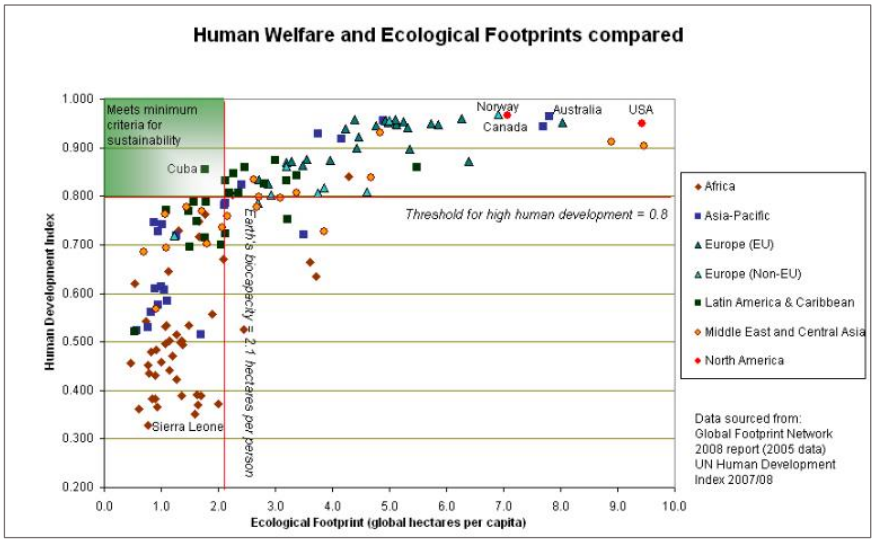

Figure 8. Graph showing Human Development Index and Ecological Footprint. The "sustainable" criteria of ecological footprint within global capacity, and human development index above 0.8, is shaded. "File:Human Welfare and Ecological Footprint Sustainability.Jpg," *Wikipedia*, n.d., accessed May 4, 2021, https://en.wikipedia.org/wiki/File:Human_welfare_and_ecological_footprint_sustainability.jpg.

The republic of Cuba's communist political system is a model in stark contrast to most of the rest of the world and has created a pattern of controlled growth.[62] It is the only country in the world which is sustainably developed (see fig. 8). If everybody on earth was to adopt the Cuban lifestyle, humans would have an acceptable standard of living and would operate at 80% of our planet's ecological capacity.[63] In comparison, if the world population

[62] Though perhaps in part ideological, the US Cuba trade embargo has likely contributed to such a degree of self-sufficiency and sustainability.

[63] In contrast to the commonly used economic metric of gross domestic product or GDP, 'The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions.'
"Human Development Index (HDI) | Human Development Reports," accessed March 28, 2021, http://hdr.undp.org/en/content/human-development-index-hdi.

adopted the lifestyle of US citizens, five planet Earths would be required to sustain it. This indicates how an alternative political system can offer a way to survive sustainably and achieve comparably high levels of human development.

Cuba is not raised as a solution (many would denounce the cost to human rights that this model of society might imply); the purpose of this research is not to argue for one political system over another. And yet the politics of inequity and hierarchy have emerged as significant themes of this project.

A Great Anthropocene

Cross-platform thinktanks, agencies, journals and collectives have emerged over recent years bringing with them mission statements, manifestos and articles designed to address the questions of climate change and its consequences for society, such as *Welcome to the Anthropocene! Ecomodermism*, *The Breakthrough Institute* and *The Dark Mountain Project*. Such initiatives represent a plurality of interests ranging from economic to artistic, but all are united by the concerns of the Anthropocene and its repercussions for the future of human life. They address serious and urgent issues and yet also reveal problematic arguments and oversimplification of complex problems. For example, the *Ecomodernist* manifesto argues for market driven technical solutions to climate change that can also contribute towards continued growth and hegemony of an established neoliberal global economy, leading to, 'a good or even a great Anthropocene.' [64] In their view this can be achieved by decoupling society's needs from its dependence on ecological systems. This view does not address the wider issue elucidated by the social ecologist Murray Bookchin that 'political structures can be no less

[64] "An ECOMODERNIST MANIFESTO," *An ECOMODERNIST MANIFESTO*, accessed March 28, 2021, http://www.ecomodernism.org.

technical than tools and machines.'[65] Bookchin's point is that building new nuclear power stations, mass marketing solar panels and developing carbon capture technology ignores the existing superstructural machinery of political subjectivity. He suggests it was the evolution of human hierarchies (an example being slavery) in societies that at the same time created the conditions for human hegemony over the natural nonhuman world. In Bookchin's view we can only effectively approach sustainability through a dissolution of these power structures and an evolution towards a framework of libertarian social ecology or eco-anarchism.

The Techno-Fix

In February 2020, electronic musician and visual artist Grimes (real name Claire Boucher) released her album *Miss Anthropocene*[66] and in May that year sold 'a fraction of her soul' to the highest bidder in her Los Angeles exhibition *Selling Out.*[67] In February 2021 she auctioned editions of her digital artwork online (made in collaboration with her brother) for 5.8 million USD, sold as NFGs (non-fungible tokens).[68] NFG's are a form of cryptocurrency which according to a recent Guardian report is now consuming electrical power comparable to the carbon footprint of

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[65] Murray Bookchin, The Ecology of Freedom: The Emergence and Dissolution of Hierarchy (Oakland, CA: AK Press, 2005), 328

[66] Grimes, *Miss Anthropocene* (4AD, 2020).

[67] "Bloomberg - Are You a Robot?," accessed March 28, 2021, https://www.bloomberg.com/tosv2.html?vid=&uuid=6a82f730-8fe6-11eb-b37a-ab224da8110f&url=L25ld3MvYXJ0aWNsZXMvMjAyMC0wNS0yOC9ncmltZXMtYXJ0LXByb2plY3QtcG9wLXN0YXItc2VsbHMtYS1waWVjZS1vZi1oZXItc291bA==.

[68] "We Regret to Inform You That Grimes Just Sold $5.8 Million Worth of Her NFT Crypto Art in Less Than 20 Minutes," *Artnet News*, last modified March 2, 2021, accessed March 28, 2021, https://news.artnet.com/art-world/grimes-sold-nft-art-1948177.

Argentina. [69] Grimes announced the donation of an undisclosed percentage of the profits from the sale of her artwork to *Carbon180*, an NGO working with 'policymakers, scientists and businesses' [70] to reduce atmospheric carbon emissions. Its website banner states: 'we can fix climate change'. Grimes, on the one hand endorses crypto currency with its significant carbon footprint and on the other hand funds carbon reduction initiatives – is this symbolic of greenwashing, virtue signalling or an ironic, knowing play? Grimes's partner, the business magnate Elon Musk [71] has succeeded in generating vast fortunes through the successful marriage of advanced technologies and commerce. After cofounding PayPal, he launched Tesla electric cars and more recently founded SpaceX. In 2021 he announced his XPrize competition that offers a 100 million USD prize for CO2 capture technology that can meet the demands of capturing the estimated annual 10 gigatons output of CO2 by 2050. [72] Despite advocating the need to approach the problems of carbon emissions, Musk seems more invested in his company SpaceX and its ambitions for extra-terrestrial exploration on Mars. An animation from Grimes's recent digital artworks auction depicts a white winged cherub-cyborg hybrid figure

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[69] Lauren Aratani, "Electricity Needed to Mine Bitcoin Is More than Used by 'Entire Countries,'" *The Guardian*, February 27, 2021, sec. Technology, accessed March 28, 2021, https://www.theguardian.com/technology/2021/feb/27/bitcoin-mining-electricity-use-environmental-impact.

[70] "Carbon180," *Carbon180*, accessed March 28, 2021, https://carbon180.org.

[71] Her Mister Anthropocene? With whom she has a child named X Æ A-XII. Musk, on hearing the name back in an interview laughed and said that it sounds like a computer password.
"Elon Musk Says His Baby's Name 'sounds like a Password' after Reporter's Mispronunciation," *The Independent*, last modified September 11, 2020, accessed March 28, 2021, https://www.independent.co.uk/life-style/elon-musk-baby-name-reporter-pronounce-x-ae-12-grimes-b422158.html.

[72] "XPRIZE Carbon Removal," *XPRIZE*, accessed March 28, 2021, https://www.xprize.org/prizes/elonmusk.

with glowing eyes and armed with a sword, floating above the planet Mars. [73] Whilst we can only speculate as to how considered the collaborative nature of their work is, Musk and Grimes nevertheless position themselves as cultural and technological protagonists in this moment of the Anthropocene and have surrounded themselves in a haze of moral ambivalence where art and corporate venture collaborate in the direction of a white supremacist, weaponised, extra-terrestrial, colonial imaginary.

We might not expect even reasonable ethical principles from a global business magnate such as Musk, but it is also difficult to follow the provocative logic of Grime's artistic output given the high stakes of the context of her work - ecological catastrophe. Both Musk's and Grimes's efforts appear to contribute towards the valorisation of techno-mercantile 'solutions' to ecological emergencies.

With an estimated net worth approaching 200 billion USD, Jeff Bezos's wealth currently outranks Musk by a relatively small margin. According to Forbes billionaires list, Bezos is currently considered the wealthiest person in the world. The founder of Amazon recently announced his intention to devote more time away from online commerce to focus on his space rocket project Blue Origin. [74] Bezos envisions colonising the moon with giant space stations designed to 'relieve the stress on earth and make it more liveable'. He describes them as 'very large structures, miles on end, and they hold a million

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[73] For artwork images see "Nifty Gateway," accessed March 28, 2021, https://niftygateway.com/collections/warnymphvolume1open.

[74] Kate Duffy, "After Amazon, Jeff Bezos Will Devote His Time to Building Multi-Billion Dollar Rockets. Here's How His Space Company, Blue Origin, Hopes to Colonize the Solar System.," *Business Insider*, accessed March 28, 2021, https://www.businessinsider.com/jeff-bezos-blue-origin-stepping-down-amazon-ceo-space-2021-2.

people or more each,'[75] Similarly, Musk speaks about his motivations for SpaceX as Earth's plan B:

> *If there's something terrible that happens on Earth, either made by humans or natural, we want to have, like, life insurance for life as a whole… Then, there's the kind of excitement and adventure.*[76]

The acclaimed scientist James Lovelock (who developed Gaia theory with microbiologist Lynn Margulis), claims Elon Musk is 'completely crazy,' and that, 'we'd be better off investing that money to save the earth.'[77] His most recent book argues that a new age, the Novacene will emerge from the Anthropocene and will be defined by the success of ultra-intelligent artificial intelligence beings to restore and regulate earth systems. Ultimately, being as dependant on the health of the planet as we are, they will ensure our own survival.

Is the prospect of terraforming a perpetuation of white supremacist colonial overreach or can it offer a hopeful utopian imaginary for building new worlds on our current planet? Both Bezos' and Musk's ambitions seem bound up in an undemocratic, monopolised colonial-settler venture that is thinly disguised

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[75] Kara Swisher, "Opinion | Why Are Elon Musk and Jeff Bezos So Interested in Space?," *The New York Times*, February 26, 2021, sec. Opinion, accessed March 28, 2021, https://www.nytimes.com/2021/02/26/opinion/mars-nasa-musk.html.

[76] Analysis by Jackie Wattles Business CNN, "Colonizing Mars Could Be Dangerous and Ridiculously Expensive. Elon Musk Wants to Do It Anyway," *CNN*, accessed March 28, 2021, https://www.cnn.com/2020/09/08/tech/spacex-mars-profit-scn/index.html.

[77] Hilmar Schmundt SPIEGEL DER, "'I Would Not Waste My Fortune on Colonizing Mars,'" accessed March 28, 2021, https://www.spiegel.de/international/europe/james-lovelock-i-would-not-waste-my-fortune-on-colonizing-mars-a-322a80e0-f768-45f5-b426-f8f32e6e9002.

as philanthropy or *saving humanity*.[78] Even if we agree with Lovelock about the doomed prospect of terraforming, we might also be concerned about the ethical consequences of a Musk or Bezos coding an AI system designed to save the planet.

> *In trying to examine technology and production, we encounter a curious paradox. We are deeply driven by a great sense of promise about technological innovation, on the one hand and by a thorough sense of disenchantment with its results on the other.*[79]

As Murray Bookchin articulates, the marriage of technology and capitalism is fraught with ethical challenges, that have their origins in political structures rather than the technology itself. Can artists - if they can avoid the seduction of technological apparatus - play a role to infuse ethical frameworks into these problematic relations?[80]

Cultural Responses

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[78] Both Bezos and Musk have established records of poor ethical practice towards employees - below average pay, precarious short-term contracts, poor treatment of workers, overly long shifts with few breaks. Amazon is also well known for its tax avoidance schemes. Such examples of unaccountability may not translate well into an ethics of terraforming. See: "How Ethical Is Amazon.Com Inc?," *Ethical Consumer*, last modified May 13, 2018, accessed March 28, 2021, https://www.ethicalconsumer.org/company-profile/amazoncom-inc.

[79] Murray Bookchin, *The Ecology of Freedom: The Emergence and Dissolution of Hierarchy* (Oakland, CA: AK Press, 2005), *302.*

[80] Artist Thirza Cuthand's satirical short film *Reclamation* (2018) plays out terraforming scenarios, imagining a post-apocalypse where indigenous people have reclaimed the earth after the exodus of privileged white settlers to Mars.
"Thirza Cuthand, Reclamation," accessed April 1, 2021, https://www.e-flux.com/video/357429/thirza-cuthand-nbsp-reclamation/.
Reclamation – Drama, Short, n.d., accessed April 1, 2021, https://www.youtube.com/watch?v=8t_Tt3jNMNI.

How has the Anthropocene become embedded into Western cultural experience? The Dark Mountain Project, founded by Dougald Hine and Paul Kingsnorth in the UK is a literary network of writers, poets and thinkers, and by contrast offers a somewhat darker vision of the future. Their manifesto, titled *Uncivilising*, aims towards establishing a community engaging with ecocide. Organizing publications, workshops and festivals, they describe their work as forming 'a creative space in which people can come to terms with the unravelling of much of the world we have all taken for granted, and engage in a conversation about what the future is likely to hold, without any need for pretence or denial.' [81] Here, there appears to be an avoidance of political engagement and a preference to focus on poetic reflections around the issues of ecological loss.

Dystopian fictional films and documentaries imagine the consequences of global warming or search out and imagine ways to improve conditions. Films such as Snowpiercer, Interstellar, The Day After Tomorrow and Beasts of the Southern Wild, deal with the subject in various ways, from science fiction, near future scenarios to portraying present-day communities coping with the aftermath of floods. [82]

In literature, the genre of climate fiction or cli-fi has emerged over recent years to address the issues of the Anthropocene. Pioneered over the past century by authors such as Jules Verne and J.G. Ballard, more recent contributors to this field include Kim Stanley Robinson, Margaret Atwood, and David Brin. These visions of the future are often dystopian, but a sense

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[81] "The Manifesto," *Dark Mountain*, accessed March 28, 2021, https://dark-mountain.net/about/manifesto/.

[82] Bong Joon-ho, *Snowpiercer* (CJ Entertainment, 2015).
Roland Emmerich , *Day After Tomorrow* (Paramount Pictures, , 2011).
Tim Fehlbaum, *Hell* (Paramount Pictures, 2011).
Benh Zeitlin. , *Beasts of The Southern Wild* (Entertainment One Films Canada, 2012).

of hope emerges in many of these narratives - humans are shown to be resilient and resourceful in finding ways to survive the harsh environments of the future. Kim Stanley Robinson's New York 2140 depicts an earth just over one hundred years into the future, where Manhattan is underwater; its inhabitants living in the apartments that remain above water while others inhabit cloud villages, using helium balloons to remain sky-bound. [83] The vast majority of these novels view global heating as a human legacy; however, the 2004 novel State of Fear by Michael Crichton portrays climate change as a hoax and became popular with climate deniers.

Club anthems have begun to refer to climate crisis. When releasing the 2016 track 4 Degrees [84] during the Paris Climate conference, musician ANOHNI released the following Facebook post:

> *In solidarity with the climate conference in Paris,*
> *giving myself a good hard look,*
> *not my aspirations but my behaviours,*
> *revealing my insidious complicity.*
> *It's a whole new world,*
> *Let's be brave and tell the truth as much as we can.* [85]

The poet and playwright Kae Tempest's 2016 album, Let Them Eat Chaos, zooms in on individual lives and everyday urban experiences, against a

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[83] Robinson, Kim Stanley. *New York 2140*. 2017.

[84] ANOHNI, *4 Degrees, Hoplessness* (Rough Trade / Secretley Canadian, 2016).See also Anthony and the Johnsons, *Another World* (Secretly Canadian, 2008).

[85] "Antony Hegarty's 4 Degrees: A Climate Change Anthem for Our Doomed Planet," *The Guardian*, last modified December 1, 2015, accessed March 28, 2021, http://www.theguardian.com/music/musicblog/2015/dec/01/antony-hegarty-4-degrees-climate-change-anthem-paris-conference.

backdrop of global catastrophe. Tempest collaborated on the album cover and contents with political activist and artist Peter Kennard. [86]

> *Picture the world*
> *Older than* she *ever thought that she'd get*
> *She looks at herself as she spins*
> *Arms loaded with the trophies of her most successful child*
> The pylons and mines
> *The powerplants shimmer in her still, cool breath*
> *Now, is that a smile that plays across her lips*
> *Or is it a tremor of dread?* [87]

After the release of her 2011 album and multimedia project Biophilia, [88] electronic musician Björk initiated the Biophilia Educational Project with the City of Reykjavík and the University of Iceland, aiming to 'inspire children to explore their own creativity while learning about music, nature and science through new technologies.' [89] In 2015 she published Björk: Archives, which includes transcripts of an email correspondence with ecotheorist and philosopher Timothy Morton.

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[86] Kae Tempest's album Let Them Eat Chaos featuring artwork by Peter Kennard 'The long form poem is encapsulated as both an album and a book of verse featuring artwork by British artist Peter Kennard'. Kae Tempest - Let Them Eat Chaos [Internet]. Kae Tempest. 2018 [cited 11 February 2018]. Available from: https://www.katetempest.co.uk/posts/let-them-eat-chaos

[87] Kae Tempest, extract from *Picture a Vacuum,* track one of the album *Let Them Eat Chaos*, Fiction Records, 2016

[88] Björk, *Biophilia* (One Little Indian, 2011).

[89] "Biophilia Educational Project," *Biophilia Educational Project*, accessed March 28, 2021, http://biophiliaeducational.org.

Grimes's 2020 album *Miss Anthropocene* was described in an NPR review as 'nihilistic…visceral and cryptic,[90] the album's ten tracks present seductive and haunting layered electronic sounds and songs that evoke a sense of Western Anthropocene reflexivity; and yet a host of narratives voices in the lyrics suggest a moral ambiguity or ambivalence towards its complexities. This is well described in the album's Pitchfork review:

> *In 2020, revolutionary pop stardom might try to clarify, rather than obscure, the havoc that systems wreak when it comes to, say, gender roles and social compliance, technology and surveillance capitalism, nationalism and land exploitation, or whiteness and pathological denial.*[91]

The album artwork, referencing her gallery and on-line exhibitions, depicts Grimes in a dystopian punk sublime – alluding to visions of posthuman sci-fi, redolent of the films Mad Max and Blade Runner.

In contrast, the work *Become Ocean* (2014) by classical composer John Luther Adams (not to be confused with John Adams), commissioned by the USA Seattle Symphony offers no such ethical ambiguity.[92] The album won the 2014 Pulitzer prize for music and was described as 'a haunting orchestral work that suggests a relentless tidal surge, evoking thoughts of melting polar

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[90] ""Review: On 'Miss Anthropocene,' Grimes Crafts Pop Both Visceral And Cryptic," *NPR.Org*, accessed March 28, 2021, https://www.npr.org/2020/02/24/808839481/review-on-miss-anthropocene-grimes-crafts-pop-both-visceral-and-cryptic.

[91] "Grimes: Miss Anthropocene," *Pitchfork*, accessed March 28, 2021, https://pitchfork.com/reviews/albums/grimes-miss-anthropocene/.

[92] John Luther Adams, Become Ocean (Cantaloupe Music B00L5VZL4S, 2014).

ice and rising sea levels'.[93] Adams splits his time between Mexico and Alaska, much of it spent alone in the wilderness. On repeated listening, this orchestral composition evokes a profound awareness and tacit affinity with natural elements as life-force. As its title suggests, the ocean seems to speak through him in this work.

The planetary scope of the Anthropocene has not been ignored by the globalised world of contemporary art, becoming the subject of research initiatives, international exhibitions, biennials, and conferences. Projects led by art practitioners and curators have begun to search out new and alternative cultural and political models that the Anthropocene provokes. In the art world, discussion and debate around the Anthropocene has engaged with scientists, anthropologists, art historians, cultural critics, and philosophers. In 2013 The Haus Der Kulturen Der Welt in Berlin Germany began a two-year programme of publications and ongoing activities including an *Anthropocene Curriculum*, and most recently *The Shape of Practice* (2020-21), that brought together presentations of over one hundred artists practices.[94] *The Great Acceleration, Art in the Anthropocene*, at the 2015 Taipei Biennial curated by Nicolas Bourriaud, was the first biennial to directly address this theme. In 2014 the Serpentine Gallery presented *Extinction Marathon* with Gustav Metzger which led to a series of ongoing exhibitions and online events in response to climate breakdown, including *Today We Reboot the Planet*

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[93] "Alaskan Composer Wins Pulitzer For 'Become Ocean,'" *NPR.Org*, accessed March 28, 2021, https://www.npr.org/sections/deceptivecadence/2014/04/14/303030185/alaskan-composer-wins-pulitzer-for-become-ocean.

[94] Haus der Kulturen der Welt, "The Shape of a Practice," *HKW*, last modified December 1, 2020, accessed April 22, 2021, https://www.hkw.de/en/programm/projekte/2020/the_shape_of_a_practice/the_shape_of_a_practice_start.php.

(2013), *General Ecology* and *Back To Earth*.[95] Other recent exhibitions and projects tackling this theme include *Yes Naturally: How Art Saves the World* (2013) at Gemeentemuseum Den Haag, *Garden of Earthly Delights* (2019), Gropius Bau Berlin, and *Eco Visionaries* at the Royal Academy (2019).[96] In December 2018 Tate Modern hosted Olafur Eliasson's *Ice Watch* installation. The charitable organisation Julie's Bicycle supports the arts in raising awareness of climate breakdown and ecological emergency through consulting, networking events and hosting online resources, with the ethos 'that the creative community is uniquely placed to transform the conversation around climate change and translate it into action.'[97]

Anthropocene Visual Art and Theory

Writers and theorists including Jill Bennet, Dipesh Chakrabarty, TJ Demos, Donna Haraway, Timothy Morton Bruno Latour, Anna Tsing, Denise Ferriera da Silva, Sylvia Wynter and Kathryn Yusoff discuss the Anthropocene from the perspective of philosophy, art theory, decolonialism, anthropology and the social sciences. The process of reflecting on this new era embraces precarity and addresses centuries of ignoring the unknown potential scenarios of long-term planetary extraction and toxicity. Theorist Jill Bennet draws analogies with contemporary conflict and wars, describing the paradigm shift

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[95] "General Ecology," *Serpentine Galleries*, accessed April 22, 2021, https://www.serpentinegalleries.org/general-ecology/.
"Back to Earth," *Serpentine Galleries*, accessed April 22, 2021, https://www.serpentinegalleries.org/whats-on/back-to-earth/.

[96] For a discussion on artist practices see section 3.3 Utility and Utopia in Art.

[97] "About Us," *Julie's Bicycle*, n.d., accessed April 22, 2021, https://juliesbicycle.com/why-we-exist/about-us/.

of the Anthropocene as ‘a full-blown culture war that has brought terrorism into our everyday lives.’ [98]

Within these discussions the term itself has attracted controversy due to the inflection that global climate problems are an equally shared human responsibility. Alternatives proposed by Donna Haraway include Capitilocene, Chthulucene, and Plantationocene. T J Demos prefers Capitilocene [99] and directs responsibility directly towards Global North corporations and governments. Demos claims that the term Anthropocene unfairly lays emphasis on a shared individual culpability or agency, that it unjustly shames those majorities of world populations that are neither responsible for contributing towards the problems associated with climate change, nor empowered to implement or influence necessary long-term change. He sees accountability sitting squarely at the corporate and government level originating in the Global North and in his 2017 book *Against the Anthropocene*, argues that consistent data produced over recent decades has long pointed to the need for large scale policy and infrastructure change within these corporations. That this has not taken place can only be the responsibility of those states and corporations themselves. However, it is hard to avoid the idea that the act of witnessing climate change and ecological destruction is itself a form of incrimination that points to varying degrees of collective and individual responsibility at all levels of society. [100]

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[98] Jill Bennett, *Living in the Anthropocene =: Leben Im Anthropozän* (Ostfildern: Hatje Cantz, 2011), 6.

[99] T. J. Demos, Against the Anthropocene: Visual Culture and Environment Today (Berlin: Sternberg Press, 2017), 53-54.

[100] On this writer Amitav Ghosh says ‘When future generations look back …they will certainly blame the leaders and politicians of this time for their failure to address the climate crisis. But they may well hold artists and writers to be equally culpable — for the imagining of possibilities is not, after all, the job of politicians and bureaucrats.’ Amitav Ghosh, *The Great Derangement: Climate Change and the Unthinkable*, The Randy L. and

> *One of the things that modern society has damaged, along with ecosystems and species and the global climate, is thinking. Like a dam, Nature contained thinking for a while, but in the current historical situation, thinking is about to spill over the edge.* [101]

Many references to the Anthropocene point to an apocalyptic eschatology, an aestheticized doomsday culture also evident in the conclusions of Microsoft scientist Professor Stephen Emmott – 'the problem is us' and 'I think we're fucked.' [102] This view has also become an aestheticized language in art practice. T J Demos refers to the work of Canadian Photographer Edward Burtynsky describing his large format images as 'seductive as they are horrific… in an extremely disturbing manner when it comes to Anthropocene visualisations.' [103] The ambiguous criticality embodied by such work reflects a tendency to dwell on near time scenarios and ignore long-term thinking. Donna Haraway argues that the Anthropocene should be treated as a 'boundary event.' Referencing geological strata, she continues 'I think our job is to make the Anthropocene as short/thin as possible and to cultivate with

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Melvin R. Berlin family lectures (Chicago: The University of Chicago Press, 2016).

[101] Timothy Morton, *The Ecological Thought* (Cambridge, Mass: Harvard University Press, 2010), Kindle Locations 59-60.

[102] 'Rather than defining humanity as the destroyer of nature, the Anthropocene casts people in an affirmative, long-term role… It is about answering the question of what impact today's population is having on the Earth in the years 2050, or 2500 or 25000.102.' Christian Schwägerl, *The Anthropocene: The Human Era and How It Shapes Our Planet* (Santa Fe, NM: Synergetic Press, 2014), Kindle Locations 1501-1504.

[103] T. J. Demos, Against the Anthropocene: Visual Culture and Environment Today (Berlin: Sternberg Press, 2017), 62.

each other in every way imaginable epochs to come that can replenish refuge.' [104]

The Anthropocene unravelling may not be easily viewed in a hopeful or positive light. It is some consolation that researchers, experts in this field, such as Morton, Crutzen, Haraway, and the writer Christian Schwägerl [105] remain optimistic in their outlooks, suggesting that the Anthropocene can offer positive opportunities for transformation. Theorising alternative, long-term ant-anti utopian visions can create contexts for and facilitate the urgent changes required in the present, to prevent worsening ecological damage. Transporting ourselves into the future will offer perspectives to better reimagine our present.

This investigation argues that the prospect of scarcity, in political and material terms, can also present an opportunity for reflection and extrapolation of transformative newly connected, hybrid structures of thinking that offer potential to translate into corrective, non-hierarchical, reparative responses. [106] Artists will not solve the problems of the Anthropocene;

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[104] Donna Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities* 6, no. 1 (2015): 159–165.

[105] 'The Anthropocene idea could, however, lead to a 'Growth of the Limits' not in the sense of continual economic growth—but in the sense of social, cultural, spiritual, scientific, and economic renewal. This was the argument behind an editorial in Nature, which stated that Crutzen's idea could eventually lead to a new global ethos: "It would encourage a mindset that will be important not only to fully understand the transformation now occurring but to take action to control it.' Christian Schwägerl, *The Anthropocene: The Human Era and How It Shapes Our Planet* (Santa Fe, NM: Synergetic Press, 2014), Kindle Edition 1501-1504.

[106] `Life typically becomes an object of reflection when it is seen to be under threat.'
Zylinska, Joanna, Minimal Ethics for the Anthropocene Open Humanities Press, Michigan Publishing, University of Michigan Library, 2014.

however, they may be positioned to influence how it is theorised and collectively and culturally experienced by offering critical, conceptual and speculative responses to questions relating to the scientific, political and social questions of this period. [107]

A central challenge of the Anthropocene is perhaps to connect this urgent need for action, not with impulsive 'presentist' [108] responses, but with actions founded on longer term consideration and reflection, [109] and in doing so address this antithetical tension between action in the now and re-engaging with utopian imaginaries towards an *archaeology of the future.* [110]

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[107] See Kayla Anderson. Ethics, Ecology, and the Future: Art and Design Face the Anthropocene, Leonardo, Vol. 48, No. 4, pp. 338-347, 2015.

[108] See the essay: Marek Tamm, "How to Reinvent The Future?" *History and Theory* 59, no. 3 (September 2020): 448–458.

[109] This is perhaps where Dipesh Chakrabarty, connecting human history with geological time finds efficacy, in connecting to modalities of deep time thinking.
Dipesh Chakrabarty, "Anthropocene Time," *History and Theory* 57, no. 1 (March 2018): 5–32.

[110] Here I use the title of Fredric Jameson's book *Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions.*
Fredric Jameson, Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions (New York: Verso, 2005).

3.3 Utility and Utopia in Art

> *All artists are alike, they dream of doing something that's more social, more collaborative, and more real than art.* [111]

The notion of utopia, it might be argued, is an adaptive trait, a driver of human survival, activated by the space of the imagination to conceive how to better live. The theory of Evolutionary Aesthetics argues that we find a landscape beautiful because in that moment we sense the opportunity and potential for improved living conditions. [112] Accordingly, the space of imagination and creativity seems inextricably linked to conceptions of amelioration (and therefore ethical reflection). [113] As one such creative context denoting a poetic space of imagination, reflection and creative autonomy, visual art has a long-established history of engaging with utopian narratives. This section explores the concept of utopia in relation to art, technology, and utility.

Art and Usership

Throughout the rapid technological and cultural change of the post war period, the evolution and divergences of Western artistic practices have seen significant shifts away from the firm ground of 19th century aesthetic philosophy of Western art, originating in Aristotle's hypothesis of art as memetic experience and Kant's notions of disinterested contemplation, the

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[111] Attributed to Dan Graham in: Claire Bishop, "The Social Turn: Collaboration and Its Discontents," *Artforum International* 44, no. 6 (2005), 178.

[112] Hannes Rusch and Eckart Voland. , "Evolutionary Aesthetics: An Introduction to Key Concepts and Current Issues," *Aisthesis* 6, no. 2 (2013), 113-133.

[113] This may also help better understand the importance of cultural surplus and the protection of cultural spaces outside capitalism, as referred to by Naomi Klein, that allow space and freedom for collective thinking and ethical reflection. Klein argues that capitalism is eroding these freedoms.

autonomous artwork and universal experience.[114] Denis Dutton stated, 'people enjoy art for art's sake and don't demand that it keep them warm or put food on the table'.[115] In recent decades however, there have been many examples of artists whose practices have branched away from these

[114] 'When art slowly but surely pried open a new social space for itself in nineteenth-century European society, on the basis of aesthetic principles laid out by Kant, Hegel, Diderot and others, it was in the name of giving itself its own laws. Its 'conquest of space,' as Pierre Bourdieu calls it, was about wresting art from the overarching control and hindrance of religious and political authorities, carving out a separate sphere for itself where it could develop in keeping with its own internal logic. This space of autonomous art determined the art of modernity. Of course, the autonomy was only ever relative – but it was effective, and jealously guarded. In fact it still is. Incursions from other fields were repulsed vigorously. Indeed, they still are. This autonomous sphere was seen as a place where art was free from the overcodes of the general economy (its own, utterly unregulated market notwithstanding) and the utilitarian rationality of market society – and as such, something to be cherished and protected. This realm of autonomy was never supposed to be a comfort zone, but the place where art could develop audacious, scandalous, seditious works and ideas - which it set about doing.' Stephen Wright, *Toward-a-Lexicon-of-Usership* (Eindhoven: Van Abbemuseum, 2013), 12, https://www.arte-util.org/cms/wp-content/uploads/2015/03/Toward-a-lexicon-of-usership.pdf.

[115] Dutton identified six universal signatures in human aesthetics: 1) Expertise or virtuosity. Humans cultivate, recognize, and admire technical artistic skills. 2) Nonutilitarian pleasure. People enjoy art for art's sake, and don't demand that it keep them warm or put food on the table. 3) Style. Artistic objects and performances satisfy rules of composition that place them in a recognizable style. 4) Criticism. People make a point of judging, appreciating, and interpreting works of art. 5) Imitation. With a few important exceptions like abstract painting, works of art simulate experiences of the world. 6) Special focus. Art is set aside from ordinary life and made a dramatic focus of experience.
"Denis Dutton on Aesthetic Universals," accessed March 28, 2021, http://www.denisdutton.com/universals.htm.

conditions towards incorporating utilitarian elements, [116] without necessarily precluding romantic, ethical or metaphysical concerns.

Figure 9. Mierle Laderman Ukeles, *Touch Sanitation Performance,* 1979, Marcia Bricker/courtesy Ronald Feldman Fine Arts.
"Touch Sanitation," *Ronald Feldman Gallery*, accessed March 29, 2021, https://feldmangallery.com/exhibition/096-touch-sanitation-ukeles-9-9-10-5-1984.

In 1969 Mierle Laderman Ukeles (fig. 9) pioneered this dismantling of the art and life dichotomy with her *Manifesto for Maintenance Art*. Describing her multiple roles as artist, mother, partner and cleaner, she declared, 'I will simply do these maintenance everyday things, and flush them up to consciousness, exhibit them, as Art. [117]

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[116] Utility in artworks often coexists with romantic or metaphysical concerns. One does not exclude the other. Beuys saw the task of planting of trees as a mystical act.

[117] Seeing the NASA depictions of space junk that Bruno Latour describes in collaboration with his students on Anthropocene markers we might imagine a revised planetary 'maintenance manifesto' and sanitation project for the Anthropocene.
Bruno Latour, *Anthropocene and Satellite Debris*, 2020, accessed March 28,

> *Ukeles was interested in how artists could use the concept of transference to empower people to act as agents of change and stimulate positive community involvement toward ecological sustainability.* [118]

Another example of utility in art practice is the Joseph Beuys work *7000 Oak Trees* (begun in 1982 for Documenta Kassel Germany), where Beuys, together with volunteers, planted oak trees across the city of Kassel.[119] Adopting the roles of artist, eco-activist, mystic, politician, and teacher, Beuys embodied the breaking down of the hierarchies and conventions of art practice. As a professor of the Art Academy in Dusseldorf he encouraged members of the public to participate in his class meetings and lectures.[120] Significantly, in these examples artistic activities exist largely away from the edifice of the art institution (though not without institutional support), signifier of status, hierarchy and historical interpretation, and move into the public sphere. In his 2002 essay The Art of Resistance: Towards a concept of Nominalism, Rasheed Araeen discusses Beuys's *7000 Oak Trees* and extends this reparative practice of the everyday into a rejection of the concept of

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2021, https://vimeo.com/393270175.

[118] Since 1977, Ukeles has acted as artist in residence at the New York City Department of Sanitation and realized radical public art as public culture in a system which serves and is owned by the entire population.' "Mierle Laderman Ukeles: Maintenance Art Works 1969–1980," *Arnolfini*, accessed March 28, 2021, https://arnolfini.org.uk/whatson/mierle-laderman-ukeles-maintenance-art-works-1969-1980/.

[119] Large scale tree planting is now recognized as a simple, low cost and effective means of carbon capture. Jill Bennett describes the work as, 'not an urban gallery exhibit "about" environmental-ism, but the reconfiguration of the cultural sphere as environment'. Jill Bennett, *Living in the Anthropocene =: Leben Im Anthropozän* (Ostfildern: Hatje Cantz, 2011), 15.

[120] See: "Appealing for an Alternative: Ecology and Environmentalism in Joseph Beuys' Projects of Social Sculpture," accessed March 28, 2021, http://www.seismopolite.com/appealing-for-an-alternative-ecology-and-environmentalism-in-joseph-beuys-projects-of-social-sculpture.

property and ownership, and a reinstatement of the commons or co-ownership. He applies this to objects (including art objects), land and architecture,

> *...only when the very idea of individual private property, on which the idea of individualism in art is based, is confronted, abolished and is dissolved into a collective process of creativity and ownership, can a new art of positive and affirmative nature emerge as part of the material production in which people are themselves involved.* [121]

Figure 10. Agnes Denes, *Wheatfield – A Confrontation,* 1982. Two acres of wheat planted and harvested inn Battery Park Landfill, downtown Manhattan. Commissioned by Public Art Fund, New York City. Photo Agnes Denes. "Agnes Denes," accessed March 29, 2021, http://www.agnesdenesstudio.com/works7.html.

Over recent generations such approaches have led to the emergence of new artistic fields, now recognised under the monikers of social sculpture, social practice, participatory art, and collective practice, as seen in the work of

[121] Rasheed Araeen, "The Art of Resistance: Towards a Concept of Nominalism," *Third Text* 16, no. 4 (December 2002): 451–466.

artists and art collectives such as Agnes Denes (fig. 10), N55, Superflex, Marjetica Potrč and Tania Bruguera. This direct engagement with society *as practice*, is often informed by or aims towards utopian ontologies and in doing so critiques an existing societal and political laissez-faire or status quo. It challenges orthodoxies: of authorship, of where the artwork is located and the timeframe of the artwork. It provokes questions such as: is the artwork found in the activity itself, in documentation of the activity, or in the impact of the activity on its environment or participators within temporal frameworks?

In 2011 the Cuban performance artist and activist Tania Bruguera presented her paper *Introduction on Useful ArtPolitical,* at Queens Museum of Art in New York, initiating an international collaboration with artists and curators to form the association of Useful Art, or Arte Útil.[122] The association has formed alliances with museums across the world and its website invites projects to be uploaded as part of an archive which is presented in exhibitions and conferences internationally. Bruguera developed criteria for Arte Útil in collaboration with curators at the Queens Museum, New York, Van Abbemuseum, Eindhoven and Grizedale Arts, Coniston, stating that it should:

> *1. Propose new uses for art within society*
> *2. Use artistic thinking to challenge the field within which it*
> *operates*
> *3. Respond to current urgencies*
> *4. Operate on a 1:1 scale*
> *5. Replace authors with initiators and spectators with users*

[122] The term was first used by Eduardo Costa in his 1969 manifesto. "Eduardo Costa's Manifesto on Useful Art, 1969 | Immigrant Movement International," n.d., accessed March 29, 2021, http://immigrant-movement.us/wordpress/2011/04/eduardo-costas-manifesto-on-useful-art-1969/.movement.us/wordpress/2011/04/eduardo-costas-manifesto-on-useful-art-1969/

6. Have practical, beneficial outcomes for its users
7. Pursue sustainability
8. Re-establish aesthetics as a system of transformation [123]

In 2014 the association commissioned the Canadian art theorist Stephen Wright's *Toward a Lexicon of Usership*. [124] Described as 'a textual tool kit for users', the publication focuses on the terminology of emergent concepts and *modes of usership* rather than offering specific examples of art works or applications, thus marking a significant turn towards a critique of such practice.

> *...aesthetic function has become almost ontologised – as if that historically determined (and altogether recent) function were inseparable from art's very mode of being... exactly what Kant had hoped for. This accounts for the reticence amongst some practitioners to envisage the deactivation of art's aesthetic function. Other practitioners, however, have concluded that it is only by deactivating this debilitating, use-precluding function that they can make way for a purposive aesthetics of art; an aesthetics repurposed in the name of usership.* [125]

To avoid confusion and ambiguity with the terms 'art' and its 'function' I borrow Wright's terms 'usership' and 'usology' along with Bruguera's 'Arte Útil' in describing art based on the conditions of utility. It might be argued that Arte Útil or art as usership invokes utopian speculation to subvert or disrupt norms and conventions that belong to existing established political structures relating to exchange, capital, and inequality. And it achieves this

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[123]"Arte Útil / Arte Útil," accessed March 29, 2021, https://www.arte-util.org.

[124] Stephen Wright, *Toward-a-Lexicon-of-Usership* (Eindhoven: Van Abbemuseum, 2013), https://www.arte-util.org/cms/wp-content/uploads/2015/03/Toward-a-lexicon-of-usership.pdf.

[125] Stephen Wright, Toward-a-Lexicon-of-Usership, 19.

by constructing temporary, speculative frameworks that require spectator participation (usership) and aim to test scenarios that rethink structures and conditions of everyday experience. Examples here include the social and community interventions of architect and artist Marjetica Potrč and Peter Fend's long term research and government lobbying in support of growing algae to produce biogas as an alternative to fossil fuel. These modalities adopt not just the appropriation and use of everyday utilitarian objects as artistic practice, but also have led to the making of objects themselves for technical utility, engaging the spectator directly in a relationship of usership. Despite achieving visibility and impact in the art world, these methods have not received a great deal of attention from critical theory [126] (beyond the work of Bruguera, curator Nato Thompson and Stephen Wright), and specifically in reference to the nature of the exchange between artist, artwork and spectator (or user).

[126] Artists have experienced difficulty being understood in this kind of interdisciplinary work. Peter Fend describes 'the intersection between discipline [as] a no-man's-land for scientists, researchers & academics.' "Peter Fend: 'What To Do Next?,'" *Underground New York*, December 7, 2012, accessed March 29, 2021, https://undergroundnewyork.wordpress.com/2012/12/07/peter-fend-what-to-do-next/.

Figure 11. Catalogue pages from The Interventionists: Art in the Social Sphere, curated by Nato Thompson and Gregory Sholette at The Massachusetts Museum of Contemporary Art.
accessed March 29, 2021, http://www.gregorysholette.com/wp-content/uploads/2011/04/Interventionists_03_14_041.pdf.
Figure 12. Catalogue pages from The Interventionists: Art in the Social Sphere, curated by Nato Thompson and Gregory Sholette at The Massachusetts Museum of Contemporary Art.
accessed March 29, 2021, http://www.gregorysholette.com/wp-content/uploads/2011/04/Interventionists_03_14_041.pdf.

Technology and Usership

What are the precedents of Western art and its relationship with technology, utility and utopian aims? Artistic interventions into everyday life and living conditions have often crossed over into design and architecture practices. [127] In the 19th and 20th centuries the aims of the Arts and Crafts movement, the Bauhaus, and Russian Constructivism set precedents for imagining a future where society's uptake of technology could enable the best possible living conditions for all, [128] seeking to build relationships between the arts and the sciences that aimed towards a synthesis of knowledge; a total vision across art, design, engineering and architecture.

> *'This is our century: machine-technology-socialism. Come to terms with it and shoulder the tasks of the century'.* [129]

During the 20th century such attempts to influence and shape the development of technology and industrialisation met largely with failure against the metrics and global reach of capitalism. In many parts of the world artistic positions now sit uneasily with capitalist and late capitalist conditions. Artistic reflection upon society has been quick to spot the inequalities and question the moral and ethical implications of the rise of capitalism. Marxist and Post-Marxist legacies remain strongly felt within art, design and

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[127] Many artists practicing today in the area of art and technology trained in architecture. This includes Tomás Saraceno, Michael Rakowitz and Marjetica Potrč.

[128] Though Ruskin remained a proponent of utility in art, he was also critical of the social problems associated with industrialisation.

[129] Moholy-Nagy quoted in Gustav Metzger's paper Automata in History, Metzger, G. Automata in history. Studio International. March 1969, 107-109.
"File:Metzger Gustav 1969 Automata in History Part 1.Pdf - Monoskop," accessed March 29, 2021, https://monoskop.org/File:Metzger_Gustav_1969_Automata_in_History_part_1.pdf.

architecture where in many cases practitioners seek out cross-disciplinary relationships and associations with political activism. [130]

The field of visual art maintains a particularly ambiguous relationship with the direct influences of capitalism due to the awkward and uneasy relationship with commodity and patronage. Artists' work may critique capitalism but also depend on the sale of work through its system, for financial and artistic survival – creating an awkward self-reflective loop of critique. Unlike the book form, the poem or essay, the difficulty of this relationship is defined by its negation of artistic autonomy through commodification. It is therefore the more ephemeral non-object-related practices that in many cases have evolved around such critiques, manifested in movements such as Dada, Futurism, Fluxus, Mail Art, the Situationists, and more recently performative, participatory, social practice, and activist art. [131]

After the collapse of socialist political ideologies during the 20th Century, these movements have continued to influence artistic output in this field of practice. The 2004 exhibition, The Interventionists: Art in the Social Sphere (curated by Nato Thompson and Gregory Sholette at The Massachusetts Museum of Contemporary Art) is one such example, addressing artistic strategies for alternatives to the conditions of everyday living (the catalogue is described as 'a user's manual for the creative disruption of everyday life'). Art works included Snail Shell System (fig. 11),

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[130] Examples include Liberate Tate, Laboratory for Insurrectionary Imagination, The Yes Men, Ursula Biemann and Paulo Tavares. For an overview of this practice, see Peter Weibel, ed., *Global Activism: Art and Conflict in the 21st Century*, A ZKM book (Karlsruhe: ZKM, Center for Art and Media Karlsruhe, 2015).

[131] See artist Hito Steyerl's critique of the art world: "If You Don't Have Bread, Eat Art!: Contemporary Art and Derivative Fascisms," accessed March 29, 2021, https://www.e-flux.com/journal/76/69732/if-you-don-t-have-bread-eat-art-contemporary-art-and-derivative-fascisms/.

a raft/survival cabin by the collective N55, Krysztof Wodiczko's Homeless vehicle in use, seventh avenue, United States 1984 (fig. 12) and Refuge Wear clothes designed by Lucy Orta in response to the Gulf War.

Recent decades have led us into a dystopian or anti-utopian relationship with technology as is well referenced by Charlie Brooker's near-future science fiction TV series Black Mirror (*The Nosedive* and *Hated in the Nation* episodes offer effective and unsettling examples of this). [132] These disturbing and compelling stories reflect on the ubiquitous exploitation of technology to construct and perpetuate the imbalance of undemocratic corporate power and control in society. [133] Technology has not become democratised to serve society; instead its development has been steered largely by a non-governmental neoliberal agenda whose influence, answerability and responsibility can be obscure and impenetrable. [134] An episode featuring Elon Musk, Jeff Bezos and Grimes would not seem out of place. There is a sense here that Brooker's dark visions are no longer warning of potential futures but of current events. [135]

At what point did the age of possibility that led art and philosophy to embrace the potentials of technology and utility with hope and idealism for the future, transform into a post-utopian (or anti-utopian) era of acknowledgement that this imagined future would not take place? It might be argued that the decades after the 2nd World War were the time of unravelling, the missed window of

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[132] "Black Mirror" (Netflix, 2016).

[133] For example, social media, automation of production, smart phones etc., operated and controlled globally by international corporations, beyond the reach of government control.

[134] See Richard Hamilton's collages Just what is it that makes today's homes so different, so appealing? 1956, and his later update of this work Just What Is It That Makes Today's Homes So Different? 1992.

[135] See Bookchin's quote on the paradox of technological production's promise and resulting disenchantment, section 3.2, note 78.

opportunity in which this could have happened.[136] Instead, this period saw the aggressive global acceleration of extractive capitalism, annexing other ideologies without concern for environmental consequences. We might understand the golden spike of the 1950s as a point of no return.

Anti-Anti Utopia

Many visual artists are challenging the current anti-utopian understanding of the Anthropocene era, by engaging in resistance and reflexivity, by rejecting market involvement for active resistance not only to the financial structures of the art world,[137] but also to wider political concerns in issues-based practices that focus on injustice and ethical issues such as environmentalism, and identifying with utopian tropes of past ideologies and post-Marxist political models.[138] [139] This process of working through the dystopian turn

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[136] See again Jacob Darwin Hamblin on the Cold War and purposeful environmental destruction through the weaponizing of planetary processes. Jacob Darwin Hamblin, *Arming Mother Nature: The Birth of Catastrophic Environmentalism* (Oxford ; New York: Oxford University Press, 2013).

[137] Art practices also do manage to merge art market involvement with activism for example in the work of Ai Weiwei and Olafur Eliasson, although Demos argues, in many cases less successfully.

[138] 'The interest some artists had in the twenties in designing for industry and raising production had worked itself out (not surprising in obsolescence directed economies), but a general impulse to contribute to productive activity beyond the creation of art works persists - one outlet could be in the development of new forms of technology. The artist can play a part in research and development in two capacities: as a stimulant and as an inventor.' Metzger, G. Automata in history. Studio International. March 1969, p107-109.
"File:Metzger Gustav 1969 Automata in History Part 1.Pdf - Monoskop," accessed March 29, 2021, https://monoskop.org/File:Metzger_Gustav_1969_Automata_in_History_part_1.pdf.

[139] Timothy Morton also argues for playful practices that bridge the artistic and scientific, asking 'What if humanists worked with engineers on suggestions and models for far future toys, toys not bound by the

towards new transformative and reparative utopian modalities is expressed by the theorist Fredric Jameson in *Archaeologies of the Future: the Desire Called Utopia and Other Science Fictions* [140] by the term anti-anti-utopia. [141] The double negative implies the need to work through historical resistance to the concept and to 'be wary of the motives of utopia's critics.' [142]

> *...for what used to be utopia's formal flaw — how to conceive a transition to the radically new — becomes its rhetorical and political strength: it is a meditation on the impossible and an intense "spiritual concentration and preparation for another stage which has not yet arrived".* [143]

The historical failure of and resistance to utopia is addressed from feminist and environmental perspectives in Ursula K Le Guin's 1982 essay-lecture 'A Non-Euclidean View of California as a Cold Place to Be'. [144] She identifies The Great Acceleration as a Western white patriarchal utopia, '…the big yang

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temporality of current corporate needs? One could take one's prototype pacemaker and redesign it for a future two thousand years from now when the climate had changed by these and those factors, where different lifeforms were dominant.' Timothy Morton, *Dark Ecology: For a Logic of Future Coexistence*, Wellek Library lectures in critical theory (New York: Columbia University Press, 2016), 142.

[140] Fredric Jameson, Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions (New York: Verso, 2005).

[141] Jameson modified Sartre's ant-anti-communism as a way of imagining a remodelling of utopia. E. Cazdyn, "Anti-Anti: Utopia, Globalization, Jameson," *Modern Language Quarterly* 68, no. 2 (June 1, 2007): 331–343.

[142] E. Cazdyn, "Anti-Anti: Utopia", 342.

[143] E. Cazdyn, "Anti-Anti: Utopia", 233.

[144] Ursula K Le Guin, "A Non-Euclidean View of California as a Cold Place to Be," *The Anarchist Press* (1982), https://cpb-us-e1.wpmucdn.com/sites.ucsc.edu/dist/9/20/files/2019/07/1989a_Le-Guin_non-Euclidean-view-California.pdf.

motorcycle trip. Bright, dry, clear, strong, firm, active, aggressive, lineal, progressive, creative, expanding, advancing, and hot.' [145] According to Le Guin, heat is an intrinsic element of the yang utopia. Listing these yang forces of ancient Chinese philosophy and connecting this with her reading of Claude Lévi-Strauss' theory of hot and cold societies (where hot societies are resource-dependant and look beyond their local reach, whereas cold societies survived in "organic mode" within the means of their locality), these words foretold the oncoming cultural awareness, the causes and effects, of global heating and climate crisis. [146] The essay contemplates the colonial and the Atomic-Age Anthropocenes, and drawing on a range of utopian literature and influences, imagines alternative 'yin' utopian trajectories that engage with First Nation, feminist, and science fiction narratives. How are we to recognise a yin utopia? Le Guin enlists yin forces: "dark, wet, obscure, weak, yielding, passive, participatory, circular, cyclical, peaceful, nurturant, retreating, contracting, and cold,' [147]

Jameson and Le Guin approach the challenges of utopian thinking, and from different directions address the resistance it has generated, but significantly they do not reject its agency, instead they reinvent or repurpose it. In response to a 1980 Time Magazine article, titled *The Poisoning of America*, Murray Bookchin states,

> *Rarely has it been so crucial to stir the imagination into creating radically new alternatives to every aspect of daily life… the concreteness of utopian thinking may well be its most rejuvenating tonic. Whether as drama, novel science fiction, poetry… experience and fantasy must return in all their*

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[145] Ursula K Le Guin, "A Non-Euclidean View of California", 10.

[146] See my text on the event a Art Util Working Group workshop at The Calthorpe Project.

[147] Ursula K Le Guin, "A Non-Euclidean View of California", 10

> *fullness to stimulate as well as to suggest. Utopian dialogue must infuse the abstractions of social theory. My concern is not with utopistic blue prints… but with the dialogue itself as public event.* [148]

Bookchin understands utopia as a process or praxis without geographical or metaphysical limits. His thinking is founded on opposition to human-on-human and human-on-nonhuman domination and oppression that in an unequal society invokes radical transformation. It breaks from the limiting horizons that Wynter and Le Guin identify - the 'black inferno' of the 'yang utopia'. The Western walled model that confines utopia to (geographical and metaphysical) narrow limits or borders and where its overreach - colonial violence and extraction - inevitably meets with cultural failure. [149] In Bookchin's utopian *earthbound* [150] philosophy, difference and diversity are prerequisites in the processing of new alternatives and new knowledges. This reflexive utopia is self-sustaining and flourishes within its material means and

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[148] Murray Bookchin, *The Ecology of Freedom: The Emergence and Dissolution of Hierarchy* (Oakland, CA: AK Press, 2005), 432.

[149] Sylvia Wynter delves into this problem in her 1976 conference paper 'Ethno, or Socio Poetics?' – how the moment of colonial overreach destabilised the ongoing processes of exchange between humans and nature, art and culture:
'Man adapts himself to Nature, at the same time as he adapts Nature to his own exigencies. From this contradictory, dual process, springs his social and economic structure, his art, and his philosophy. This balance lay at the heart of all traditional cultures until the discovery of the New World and the concomitant expansion and mutation of Western civilization.'
Sylvia Wynter, "Ethno, or Socio Poetics?," *Alcheringa/Ethnopoetics* 2:2 (1976), 6 https://trueleappress.files.wordpress.com/2020/04/ethno-or-sociopoetics.pdf.

[150] I borrow Bruno Latour's widely appropriated term.

resources. It is in ontological terms emancipatory; creative discourse as *public event*. [151]

In his lecture 'The Idea of a Borderless World', at the university of Augsburg in 2019, The philosopher Achille Mbembe addresses utopian thinking in the context of geopolitics and asks:

> *why is it important to excavate this old utopia, to attend once again to an impossible intent? The first reason: movement or borderlessness has been central to the utopian tradition. The utopic is about the implosion, the unfixing of all borders that might put limits to the act of imagination, understood in itself as a social process, as a political process or as an aesthetic form.* [152]

Mbembe refers to this *earthbound concreteness* of utopian thinking by conflating metaphysical emancipation with the unfixing of geographical

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[151] Bookchin's ideas have influenced social and environmental movements such as the anti-nuclear movement and Occupy Wall Street in the US. Towards the end of his life Bookchin discovered that the PKK (Kurdistan Workers Party) based in northern Iraq and south eastern Turkey led by Abdullah Öcalan, were implementing his ideas on the founding of democratic confederalism (KCK) in Rojava. According to his translator Raimar Heider, Öcalan considers himself a 'good student' of Bookchin: 'He has rebuilt his political strategy around the vision of a "democratic-ecological-society" and developed a model to build up a civil society in Kurdistan and the Middle East… He has recommended Bookchin's books to every mayor in all Kurdish cities and wanted everybody to read them.' This model includes addressing gender inequalities and greening projects in areas of ecological devastation, educational programmes, and aims to pursue democracy 'without a central state'.
Debbie Bookchin, "How My Father's Ideas Helped the Kurds Create a New Democracy," *The New York Review of Books*, n.d., accessed March 21, 2021, https://www.nybooks.com/daily/2018/06/15/how-my-fathers-ideas-helped-the-kurds-create-a-new-democracy/.

[152] *Lecture of Achille Mbembe: "The Idea of a Borderless World,"* n.d., accessed March 29, 2021, https://www.youtube.com/watch?v=2oYCXNgwPqw.

political boundaries.[153] In this sense, Mbembe suggests the emancipatory potential of utopian thinking finds efficacy in decolonial discourse. This thinking offers a step towards coalescing Global North and Global South environmental solidarity.

Usership for the Anthropocene

While current art discourse continues to examine the nature and aesthetics of participatory art,[154] the related discussion surrounding artists working with usership has received comparatively little attention, despite this area of practice becoming ever more established over recent decades. Since the voices of Moholy Nagy, Buckminster Fuller and Gustav Metzger called out for an integration of art and science,[155] heralding artists as the conscience of technology's relationship with society, beyond a general move towards encouraging interdisciplinary approaches there has been little development or rethinking of these ideas in recent years.[156] While discourses on participatory practice are relevant to this investigation, it is set apart by the additional conditions of usership and specifically artwork as objects made for utility. To work towards an understanding and definition of the aesthetic experience of this practice, it is necessary to look at the relationships between the artist, the work and the involvement of the spectator as its user in this exchange.

Through my own studio practice and investigating how other artists approach this field I look for common ground and overlaps of activism, participatory

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[153] In ecological terms we might equate this kind of utopian dialogue to a *rewilding* or *recomposting* (Haraway) of thinking.

[154] Initiated by theorists including Claire Bishop, Grant Kester, Maria Lind.

[155] See Metzger's essay Automata in History.

[156] It might be argued that theories of art/science practice have been largely annexed by post-media theory, which has largely focused on the development of digital and internet practice.

art, technology and utility**,** towards an aesthetics of usership. Whereas many, if not all Bruguera's eight criteria of Arte Útil apply to this practice, focus here is on creating objects for use and how the experience of usership or the *feeling of function*, can become aesthetic experience and at the same time find agency in confronting the issues of the Anthropocene. In formulating the notion of a *feeling of function* I apply Bookchin's thinking on artisan traditions to contemporary technology:

> *Ultimately what arouses us emotionally is the fact that these objects attest to a fecund human spirit, a creative subjectivity....* [157]

In this sense the making of and engagement with technologies becomes an ethical practice, that imparts a 'surreal halo around everyday things -the reconquest of everyday life by a pulsating integration of hands, tools, mind, materials...' [158]

In relation to an interdisciplinary art practice, engaged in scientific and technological disciplines, it is also helpful to scrutinise the relationship between these fields and to consider how they may coexist within a practice. (This is further addressed in section 4.6).

> *Is there a scientific discipline that allows for the indiscipline or fancy, imagination and artfulness? Can it encompass problems created by the social and environmental crises of our time? Can it integrate critique with reconstruction, theory with practice, vision with technique?* [159]

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[157] Murray Bookchin, *The Ecology of Freedom: The Emergence and Dissolution of Hierarchy* (Oakland, CA: AK Press, 2005), 326.

[158] Murray Bookchin, *The Ecology of Freedom: The Emergence and Dissolution of Hierarchy*, 326.

[159] Murray Bookchin, *The Ecology of Freedom: The Emergence and Dissolution of Hierarchy*, 84.

Here, far from reflecting on artistic practice, Bookchin is building an argument towards defining the discipline of social ecology which he elsewhere describes as a philosophy of evolution. And yet these rhetorical questions embody the kind of practice that I propose – by identifying interdisciplinary approaches that combine the imaginary and the environmental within participatory contexts (or the social matrix). Though Bookchin did not refer to the Anthropocene - his last writings were published in the mid-1990s – he was highly sensitive to the environmental issues of the 20th century and his legacy may find renewed relevance for this new epoch.

A survey of work in this area, suggests that the topic of renewable hydrogen as a subject for investigation in the context of eco-crisis and Arte Útil is still to be addressed. The difference in approach to other art works that use hydrogen, for example, Simon Starling's 2004 *Tabernas Run* (that featured a hydrogen fuel-cell powered bicycle used to cross a dessert in Spain) is that this project, rather than using industrially produced hydrogen, (like Starling's), aims to facilitate and utilise the entire energy cycle from a water state to hydrogen gas in a series of works. Starling's work also does not approach participatory usership and so does not engage with conditions of Arte Útil as this project intends.

Examples of artworks and art practices in the field of utility and renewable energy include:

- In 1996 Superflex created *Supergas*, a biogas unit, that converts animal waste to a gas that can be used for lamps and cooking. This has been put into production and is being used in remote off-grid locations across the world.
- Peter Fend is an activist-artist concerned with fracking and global warming. He formed the organisation *Ocean Earth* that lobbies governments to take up industrial scale algae fermentation to produce methane gas as a substitute for fossil fuel.

- With a background in architecture Marjetica Potrč utilises wind turbines and solar power in her on-site projects that often combine visual art, architecture, and social science.
- Ralph Sander 2009 World Saving Machine III uses solar energy to create ice.
- The works *Tabernas Desert Run* 2004, and *Exposition* 2004, by Simon Starling feed industrially produced hydrogen into fuel-cells to make electricity.
- Lorraine Leeson's 2017 *Active Energy* project was a collaborative work that produced a water wheel turbine purposed to oxygenate water in the river Lea,
- Gilberto Esparza developed the work *Plantas Nomadas (Nomadic Plants),* 2008-13*,* a robot designed to clean polluted rivers and use them also as energy sources.
- Tomás Saraceno's *Aerocene* project uses the sun's heat to generate lift in giant air balloons for human flights.
- The work *Power Call* (2015) by artists Sue Mark and Bruce Douglas, allows participants to contribute to the energy commons by using their energy generator. Pumping the mechanical arm of the device charges cell phones.
- *Small Truck* (2005-) by N55 and Pelle Bragge is a pedal powered tiny 'truck' that can carry up to 300 kilos.
- In Maurizio Cattelan's 1997 work *Dynamo Secession*, two raised up bicycles fitted with generators were pedalled by museum guards to power gallery lighting.
- In 2000 the art collective DIAA (Dialogue Interactive Artists Association) restructured water pump sites (Nalpar) in villages in India, creating recreational spaces that are safer and healthier environments for the women that use them.
- As artist in residence at Arts Catalyst in 2018, Tom James presented *Gas Workshop*, demonstrating a self-made biogas system at The Calthorpe Project in London.

- In 2000 the community project Energia Alterniva was initiated by the art and environmentalist group Ala Plástica in response to a petrochemical spill on the banks of La Plata harbour in Argentina. The project formed an independent energy association that installed solar panels to deliver clean renewable electricity for the community.

These projects address renewable energy and utility, the majority involve participatory input in conceptualising and making the work or in activating it once it is prepared for usership. Such examples provide case studies for critical reflection and analysis that also have proven helpful in defining the parameters of and agency in my own practice.

Community and its democratic equivalent, communitas, is a central tenet in utopian thinking, and is made manifest in the architecture of idealised community, the phalanstery. Can utopian thinking and its relations with community find efficacy in a methodology that engages with 'collaborative survival', the ontology of or *being in* the ecological crisis of the Anthropocene, that accommodates its complexity and immeasurable disparities? [160]

This praxis – engaged in making and sharing technology in the context of the Anthropocene - must also counter the necro-politics [161] of Musk, Bezos and

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[160] Haraway states: 'Anthropocene is a term most easily meaningful and usable by intellectuals in wealthy classes and regions; it is not an idiomatic term for climate, weather, land, care of country, or much else in great swathes of the world, especially but not only among indigenous peoples.' "Tentacular Thinking: Anthropocene, Capitalocene, Chthulucene," accessed March 29, 2021, https://www.e-flux.com/journal/75/67125/tentacular-thinking-anthropocene-capitalocene-chthulucene/.

[161] Mbembe, Achille. "Necropolitics." *Public Culture* 15, no. 1 (2003): 11-40.

indeed the art practice of Grimes. The unambiguity of these stances also calls for unambiguous responses.

In reference to Jacques Derrida's 1968 talk 'The Ends of Man' Sylvia Wynter articulates the importance of understanding that the referent 'we' of 'man' is not the human species itself. She describes this as,

> *'...the single issue with which global warming and climate instability now confronts us and that we have to replace the ends of the referent- we of liberal monohumanist Man2 with the ecumenically human ends of the referent- we in the horizon of humanity. We have no choice.* [162]

Developing a praxis of the Anthropocene might begin in acts of opposing this problematic neoliberal, techno-mercantile 'referent-we' by working constructively and directly to address injustice, shaping a practice founded on intersectionality, anti-racism and the decolonising of technology, and its usership. Such a methodology seeks contexts of solidarity and communitas; it aims to identify and hold awareness of the 'referent we'.

In her book, *The End of Man, A Feminist Counter Apocalypse*, Joanna Zylinska with references to Anna Tsing and Judith Butler, argues for a radical ethics of precarity as the condition of being vulnerable to others:

> *This precariousness is manifested in the face, or, more broadly, the figure of a vulnerable human who both threatens my sense of security and places a demand on me. The Other's demand is a form of accusation because it requires a justification of my*

[162] Katherine McKittrick, ed., *Sylvia Wynter: On Being Human as Praxis* (Durham: Duke University Press, 2015), 24.

> *relative comfort and stability when that Other is facing a political or even existential threat.* [163]

Zylinska moves beyond the importance of recognising connectedness within encounters and relationships, towards a notion of contamination:

> *'Tsing's implicit proposal for a non-normative ethics of encounter—in which we are not told what to do but in which we are faced with a call to responsibility—finds its most direct articulation in the invitation she issues to humans to embrace cross-species coexistence as an ethical way of being in the world. Learning the lesson of "collaborative survival" in precarious times from the matsutake mushroom, she argues that "staying alive—for every species—requires liveable collaborations. Collaboration means working across difference, which leads to contamination. Without collaborations, we all die"* [164]

It is the denial of this precarity according to Zylinska that creates the conditions of separation and difference. 'In the ethics of responsibility toward the alterity of the Other, the moral subject is always already exposed, invaded, or, to use Tsing's phrase, contaminated'. Zylinska suggests this ethical entanglement offers a means of retreat from the over-reach of the patriarchal narrative towards unexpected and liberatory coexistences and collaborations. This 'call to responsibility' is a process of rethinking contamination as ameliorative – as a furthering towards 'liveable collaborations.'

Zylinska's ethical thesis seeks a fundamental recognition of mutuality in precarity and vulnerability. Through this process collaboration and

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[163] Joanna Zylinska, *The End of Man a Feminist Counterapocalypse*, 2018, accessed March 29, 2021, http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=2458648. 42

[164] Joanna Zylinska, *The End of Man*, 42.

contamination occurs. This thinking might itself contaminate the yin anti-anti-utopia as an Anthropocene praxis and offer an aesthetics of amelioration engaged in acts of communitas through mutuality (in vulnerability), creativity and futurity. Its aim: *liveable collaborations for collaborative Anthropocene survival.*

The conceptions of collaboration and contamination that Tsing and Zylinska articulate, are also at play in Peter Kropotkin's theory of mutual aid, a term that has found renewed currency in its relevance for communities affected by extreme weather events and the Covid-19 pandemic. [165] Kropotkin describes mutual aid, the reciprocal care and cooperation of humans and non-humans, as a 'factor of evolution', a law of nature,

> *It is not love to my neighbour – whom I often do not know at all which induces me to seize a pail of water and to rush towards his house when I see it on fire; it is a far wider even though more vague feeling or instinct of human solidarity and sociability that moves me.* [166]

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[165] The naturalist and anarchist Peter Kropotkin's collection of essays published in 1902 titled *Mutual Aid, A Factor of Evolution*, describes examples of animal and human behaviour as being primarily one of interdependence rather than following the Darwinian trope of competition and survival of the fittest. In the book's introduction, George Woodcock writes that Kropotkin's extensive research and observations, 'show that the sociability or mutual aid between individuals within a species is so widespread at all levels in the animal world, from insects to so called higher mammals, that it can be regarded as a law of nature.' Kniaz Petr Alekseevich Kropotkin, *Mutual Aid: A Factor of Evolution.* (Lanham: Dancing Unicorn Books, 2016), accessed April 19, 2021, http://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=4649324.

[166] This quote gains a renewed relevance in the light of Greta Thunberg's speech to the World Economic Forum, (see section 3.1) and provokes the question: can this instinct towards solidarity find efficacy in on a planetary scale to confront climate breakdown? Kropotkin*, Mutual Aid: A Factor of Evolution, 300.*

The ‘Wrong Boys’ of the *SRSLY Wrong* podcast presented an episode titled ‘You Can Create New Worlds’ about the transformative efficacy of invented words or neologisms. On the show they discuss the term ‘utop’, describing it as: ‘a partial step towards a utopia, a concrete actionable realisable goal that moves us forward in the direction of where we imagine utopia to be.’ [167] Their conception of the ‘utop’, [168] infused by Zylinka’s ethics of vulnerability, proposes an incremental ameliorative practice for the everyday; actionable and scalable in catastrophic times.

[167] “Ep 154 – You Can Create New Words – Srsly Wrong,” n.d., accessed March 29, 2021, https://srslywrong.com/podcast/ep-154-you-can-create-new-words/.

[168] This type of utopian experience is described elsewhere as a ‘micro-utopia’.
Ruy Blanes et al., “Micro-Utopias: Anthropological Perspectives on Art, Relationality, and Creativity.,” *Cadernos de Arte e Antropologia*, no. Vol. 5, No 1 (April 1, 2016): 5–20.

3.5 Hydrogen – Anti-Anti-Utopian Response?

> *Yes, my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable. Someday the coal rooms of steamers and the tenders of locomotives will, instead of coal, be stored with these two condensed gases, which will burn in the furnaces with enormous calorific power. There is, therefore, nothing to fear…I believe, then, that when the deposits of coal are exhausted we shall heat and warm ourselves with water. Water will be the coal of the future!* [169]

> *Can there be 'liveable collaborations' also with entities, substances, elements - a collaboration with hydrogen? Odourless, colourless, tasteless and invisible, on earth it is bound to compounds: coal, oil, wood and also to water. Beyond earth most stars are mostly hydrogen.* [170]

When made from water using the electrochemical process of electrolysis (see fig. 13) hydrogen has many applications: it can be combusted as a fuel for cooking and heating, and power internal combustion engines in vehicles and generators. The electrochemical reaction is reversable, allowing stored hydrogen to function as an energy carrier to produce electricity using fuel-cells. When hydrogen burns in air or is used in a fuel-cell it returns to water (its name derives from the Greek 'hydro' and 'genes' meaning water-forming). The outputs of water electrolysis – oxygen and hydrogen are non-

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[169] Jules Verne, *The Mysterious Island* (Simon & Brown, 2012), Part II, Ch. XI.

[170] Excerpt from my text written for EARN conference, publication in process.

polluting and non-toxic. The 'waste' gas, oxygen is considered an essential medicine by the World Health Organisation. In these cases, it can substitute fossil fuels without contributing to carbon dioxide emissions (global heating) and pollution in the local environment.[171] My practice explores these applications within an art practice responding to urgencies of the Anthropocene.

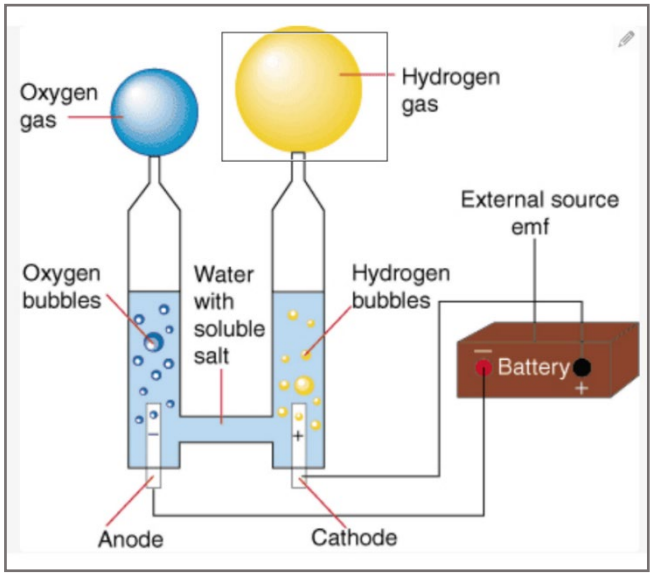

Figure 13. Electrolysis of Water, An Explanation. Creating an electric potential through water causes positive hydrogen ions to move towards the negative electrode (cathode) and negative ions to move towards the positive electrode (anode). This causes electrolysis with oxygen gas produced at the anode and hydrogen gas produced at the cathode. Paraphrased from martin.chaplin@btinternet.com. Electrolysis of water [Internet]. Www1.lsbu.ac.uk. 2018 [cited 12 February 2018]. Available from: http://www1.lsbu.ac.uk/water/electrolysis.html 2018].

[171] Hydrogen specialist Roy McAlister claims that hydrogen can even purify polluted air in the local environment when the hydrogen is mixed with air from the environment and burned in a car engine. Roy McAlister, *The Solar Hydrogen Civilization*, 2005.

Hydrogen Hype

At the beginning of the 20th century, when the first electrolysers began to decompose water into hydrogen on an industrial scale, hydrogen embodied the promise of a zero carbon, energy paradise for the future. [172] Today its everyday integration into energy infrastructure is still far from reality. In Jules Verne's 1874 novel *The Mysterious Island*, engineer Cyrus Harding predicts that energy dependence would turn to water-derived hydrogen once coal reserves became exhausted. When the character Pencroft states that he hoped to see this new energy in use, Neb remarks, 'you were born too soon'. [173]

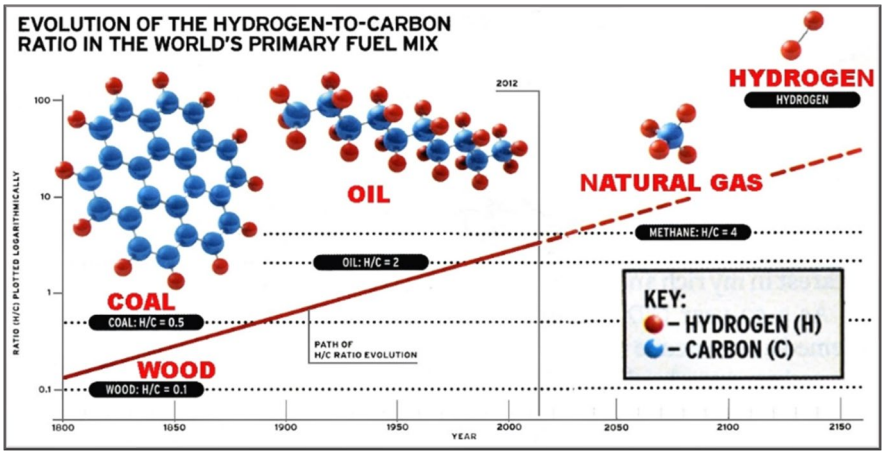

Figure 14. Evolution of the hydrogen to carbon ratio in the world's primary fuel mix. Natural Gas: The Next Step on the Road to Hydrogen - Tech Dept. - Car and Driver [Internet]. Car and Driver. 2018 [cited 12 February 2018]. Available from: https://www.caranddriver.com/features/a15118080/natural-gas-the-next-step-on-the-road-to-hydrogen-tech-dept/

[172] Joseph J. Romm, The Hype about Hydrogen: Fact and Fiction in the Race to Save the Climate (Washington, DC: Island Press, 2004).

[173] Jules Verne, The Mysterious Island.

The current dominant source of hydrogen gas is made from fossil fuels (95% in the USA [174]), from natural gas using a steam reforming process. This is known as *grey hydrogen* or *blue hydrogen* if CO2 is captured in the process and stored in the ground. [175] Despite the release of carbon dioxide as a by-product, a fuel infrastructure based on this process would still be more efficient and ecologically preferable to petroleum fuels at their point of use. [176] Conventional uses of hydrogen include ammonia production for fertilizers, oil refining, hydrogenation in fats for the food industry, plastics manufacturing, rocket fuel, and welding.

Throughout the 20th century and into the present day, fuel production has been gradually transitioning from carbon dioxide emitting hydrocarbons (coal and crude oil), towards fuel mixes increasing in hydrogen purity, a move referred to as *the age of gases*. These models predict that the global transition into the use of pure hydrogen as a primary fuel may be still over a century away (fig.14). This is not soon enough to correct or even reduce levels of carbon dioxide from hydrocarbon emissions in the atmosphere. Waiting for the depletion of oil and coal reserves to force such a changeover may be a high-risk scenario; 150 years after Verne wrote his portentous words, we might wonder if we too were born too soon to 'warm ourselves with water'.

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[174] "Hydrogen Production: Natural Gas Reforming," *Energy.Gov*, accessed March 29, 2021, https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming.

[175] Mitsubishi Heavy Industries, "What Are the Three Colors of Hydrogen," *Spectra*, accessed March 30, 2021, https://spectra.mhi.com/what-are-the-three-colors-of-hydrogen.

[176] 'Total greenhouse gas emissions are cut in half and petroleum is reduced over 90% compared to today's gasoline vehicles.' "Hydrogen Production: Natural Gas Reforming," *Energy.Gov*, accessed March 29, 2021, https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming.

Professor Paul Dodds of the UCL Energy Institute, presents a more positive outlook.[177] He applies the Gartner Hype Cycle[178] (fig.15) to hydrogen's integration into energy infrastructure and argues that it may now be on the slope of *enlightenment* and moving towards a *plateau of productivity*; a steady assimilation into everyday use.

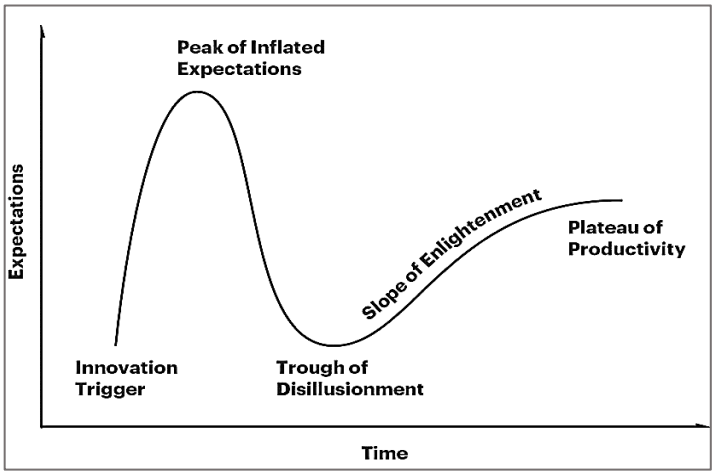

Figure 15. Gartner Hype Cycle Muhammad Raza, "Introduction to the Gartner Hype Cycle," *BMC Blogs*, accessed October 29, 2021, https://www.bmc.com/blogs/gartner-hype-cycle/.

[177] *What Happened to the Hydrogen Economy? - Dr Paul Dodds - 20/02/2018*, n.d., accessed March 31, 2021, https://www.youtube.com/watch?v=n3XdEu2Gvno.

[178] 'Gartner Hype Cycles provide a graphic representation of the maturity and adoption of technologies and applications, and how they are potentially relevant to solving real business problems and exploiting new opportunities.'
"Hype Cycle Research Methodology," *Gartner*, accessed March 31, 2021, https://www.gartner.com/en/research/methodologies/gartner-hype-cycle.

As public pressure increasingly calls for governments and corporations to act on reducing CO2 emissions, and to take seriously the task of a zero-carbon transition, hydrogen or water electrolysis powered by renewable energy, may play a growing role. Hydrogen is a key part of the European Union's response to the Paris Agreement commitment to a zero-carbon economy. [179] A recent press release announced that 126 hydrogen electrolysis projects are planned for this decade using water and renewable power to make hydrogen, which can be integrated into existing natural gas pipelines for domestic and industrial applications. Gas boiler manufacturers are prototyping systems that can use mixed gases of natural gas and hydrogen. [180] In London eight fuel-cell buses now follow the 444 London bus routes (out of a bus fleet of almost 10,000). A fleet of fifteen hydrogen fuel cell buses began serving bus routes in the city of Aberdeen in 2021. [181]

In 2018 UCL's Electrochemical Innovation Laboratory acquired a Toyota Mirai hydrogen fuel-cell car and plans to install a hydrogen filling station as part of the Advanced Propulsion Laboratory at UCL East. [182] Hydrogen is also showing potential for ocean transport. The Energy Observer is a solar hydrogen powered zero emission catamaran designed and built by Victorien

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[179] Kate Abnett, "Europe Pulls Ahead in Race for Hydrogen, as Global Project Pipeline Grows: Report," *Reuters*, February 17, 2021, accessed March 31, 2021, https://www.reuters.com/article/us-eu-energy-hydrogen-idUKKBN2AH0IB.

[180] "Hydrogen Boiler | Worcester Bosch," accessed March 31, 2021, https://www.worcester-bosch.co.uk/hydrogen.

[181] "Hydrogen-Powered Buses Start Operating in Aberdeen," *Smart Cities World*, accessed March 31, 2021, https://www.smartcitiesworld.net/news/news/hydrogen-powered-buses-start-operating-in-aberdeen-6065.

[182] UCL, "UCL Is First University to Host a Production Fuel Cell Car," *UCL News*, last modified November 20, 2018, accessed May 1, 2021, https://www.ucl.ac.uk/news/2018/nov/ucl-first-university-host-production-fuel-cell-car.

Erussard in partnership with film maker Jérôme Delafosse. Described as a 'laboratory for ecological transition',[183] it travelled over 10,000 nautical miles in 2020, experimenting with different zero carbon configurations of sails, solar panels, batteries, wind turbines, and hydrogen electrolysis from purified sea water. The *Energy Observer* is set apart from these other examples of hydrogen transport by its ability to both generate and store hydrogen for use in fuel cells – rather than relying on energy filling stations, it is energy independent. These examples show that although still far from commonplace, hydrogen technology is gaining in use and recognition. Its key disincentives are the complexity of its integration into existing centralised energy networks; unresolved issues surrounding compression and storage of the gas; the high costs of recent electrolyser and fuel cell technology; and its novelty – it has a reputation as a dangerous gas.

[183] "About Energy Observer," *Energy Observer*, accessed March 31, 2021, https://www.energy-observer.org/about.

Figure 16. LZ 129 Hindenburg airship crash, Lakeland, USA. Photo Murray Becker Photo Murray Becker Hindenburg disaster [Internet]. En.wikipedia.org. 2018 [cited 12 February 2018]. Available from: https://en.wikipedia.org/wiki/Hindenburg_disaster

Hydrogen Myths

Hydrogen has gained a somewhat mythical reputation as being volatile, dangerous and unsafe for public use. The Hindenburg airship fire in 1937 at Lakehurst, New Jersey (fig. 16), and NASA's Challenger space shuttle disaster of 1986 were both widely publicised; broadcast live by radio and television respectively. News images of huge plumes of fire and smoke created a vivid and terrifying spectacle around the tragedies that caused the loss of human lives. There are also other parallels to the disasters: consensus

points to the fires not being caused directly by using hydrogen, but human error and technical failures are claimed to be the main factors. The Hindenburg airship, already twelve hours behind schedule, attempted a hurried landing in an approaching storm. Investigators believed an electrostatic fire starting in the metallic flammable skin of the ship caused the disaster. [184] The Challenger space shuttle suffered a rubber O-ring seal failure in a rocket booster which spread to the external hydrogen tank. The disaster investigation found that the cold weather of the launch day caused the o-rings seals to fail. These technical limitations were already known by members of the management team who, going against engineers' advice, ordered the launch.

Current literature states that hydrogen is no more hazardous than other flammable gases such as liquid petroleum gas and is a safer alternative to petrol vehicles. [185] In the event of a leak, hydrogen will always dissipate into the atmosphere very quickly, rising at twenty meters per second, [186] whereas LPG, petrol fumes and butane accumulate at floor level, risking inhalation and toxicity to humans. The inhalation of hydrogen is non-toxic in

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[184] 'An investigation by NASA scientist Dr Addison Bain found that the disaster would have been essentially unchanged even if the dirigible were lifted not by hydrogen but by non-flammable helium, and that probably nobody aboard was killed by a hydrogen fire. (There was no explosion.) The 35% who died were killed by jumping out, or by the burning diesel oil, canopy, and debris (the cloth canopy was coated with what nowadays would be called rocket fuel). The other 65% survived, riding the flaming dirigible to earth as the clear hydrogen flames swirled harmlessly above them.'
Bain, Addison, and Ulrich Schmidtchen. n.d. "Afterglow of a Myth Why and How the 'Hindenburg' Burnt." Accessed March 30, 2021. https://www.dwv-info.de/wp-content/uploads/2015/11/Truth_about_Hindenburg.pdf.

[185] Fig. 55 appendix

[186] "Hydrogen: Similar but Different." n.d. Accessed March 30, 2021. https://old.arhab.org/static/h2_safety_fsheet.pdf.

comparison to hydrocarbon gases. Such evidence suggests that hydrogen offers benefits beyond its environmental claims.[187] As an energy carrier, stored in conventional steel gas bottles or in metal hydride tanks, hydrogen can be an alternative to electric battery energy storage, without the added costs - human, environmental and financial - of mined metals and chemicals used in battery manufacturing, such as lithium, cobalt, aluminium and nickel that are required for electric car batteries used by manufacturers such as Tesla.

Water Electrolysis

Water electrolysis, the decomposition of water molecules into hydrogen and oxygen gas using electrical current, currently amounts to 4% of worldwide hydrogen production,[188] This process was first discovered in 1789 by Jan Rudolph Deiman and Adriaan Paets van Troostwijk.[189] In 1869 it became practical and economical due to the invention of the electrical dynamo, a source of direct current electricity that can split water into hydrogen and oxygen (fig 17).

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[187] Ram B. Gupta, ed., *Hydrogen Fuel: Production, Transport, and Storage* (Boca Raton: CRC Press, 2009), 560.

[188] "Hydrogen Production by PEM Water Electrolysis – A Review," *Materials Science for Energy Technologies* 2, no. 3 (December 1, 2019): 442–454.

[189] Cronin, Leroy, and Chisholm, Greig. "Hydrogen from Water Electrolysis." *Storing Energy : With Special Reference to Renewable Energy Sources*, 2016, 315-43.

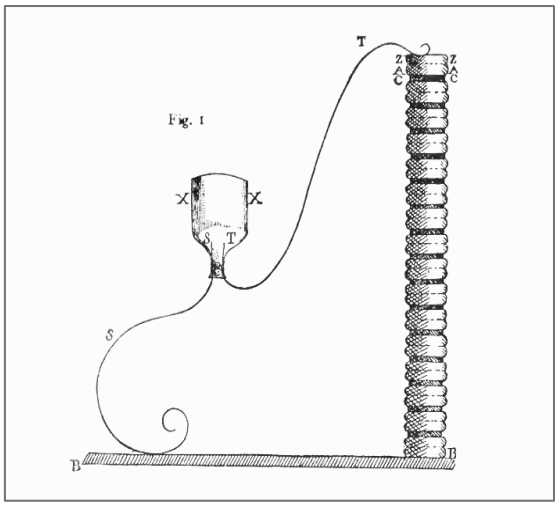

Figure 17. Apparatus used by Landriani, around 1800. An early DC battery known as a Volta Pile (right), supplies an electrical current through two wires into a flask containing water (left), where it is decomposed, forming hydrogen and oxygen bubbles. Engelhardt, V. The Electrolysis of Water, Processes and Applications; The Chemical Publishing Company, Lehigh, 1904, p.3

In the 20th century the production and use of hydrogen through electrolysis from water became safe and reliable, being used for example in life support systems for the International Space Station producing oxygen to support human life, where in this case hydrogen was the waste gas.[190] The first alkaline fuel cell was invented by Francis Thomas Bacon and demonstrated in 1960. It enabled the transformation of hydrogen into electricity.[191] The chemist and inventor Karl Kordesch built his own protype hydrogen fuel cell car in 1970 and used it for three years for daily transportation. [192]

[190] Fig .61 appendix

[191] Fig. 57 appendix

[192] Fig. 56 appendix

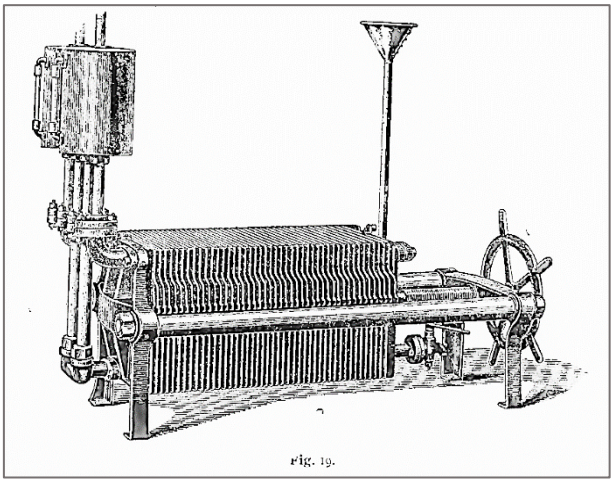

Figure 18. Schmidt Filter Press Electrolyser, 1899. This electrolyser design was one of the first successful devices to produce industrial quantities of hydrogen. Variations of this design are still in use today. Engelhardt, V. The Electrolysis of Water, Processes and Applications; The Chemical Publishing Company, Lehigh, 1904, p.30

Coupled with other technologies – photovoltaics (solar panels) or a wind turbine to supply electrical energy – an electrolyser can provide a non-polluting source of usable energy known as solar hydrogen. As an energy carrier, hydrogen can be stored and compressed in various ways, including simple pressurised carbon fibre or steel gas bottles. This avoids the need for battery storage and its associated environmental costs. Today, renewable hydrogen systems provide energy for a small number of off grid communities. One such example is on the Shetland Island of Unst, which in 2005 established the first community-owned renewable hydrogen system in Europe. [193] Another example was designed and built by civil engineer Mike

[193] "Shetland's Hydrogen Technology Pioneers," *The Telegraph*, accessed March 30, 2021, https://www.telegraph.co.uk/news/earth/greenerliving/3345109/Shetlands-hydrogen-technology-pioneers.html.

Strizki in New Jersey, US. [194] His system supplies enough energy to fulfil the needs of his house and a car allowing his family to live off-grid. The Stuart Island Energy Initiative in Canada is another example. [195] Such projects have so far been uncommon due to lack of government investment in the technology, the high technology costs and skills required to set up such a system.

In her book *Energy at the end of the World,* [196] ethnographer and poet Laura Watts describes the challenges faced by Orkney Islanders in adapting to the integration of wind and hydrogen power, as part of a European Marine Energy Centre initiative. Watts describes how wind turbines generated more electrical power than the cables connecting to the mainland could manage. Rather than shut down wind turbines to reduce their output, this situation catalysed an accidental hydrogen economy. Hydrogen electrolysers were installed. Powered by the surplus electrical wind energy, they now produce compressed hydrogen gas that is bottled and shipped to the mainland. Orkney also uses hydrogen to power vehicles – there are five hydrogen vans on the island and a hydrogen powered ferry trial is in process. Watts' account highlights the difficulties in connecting new decentralised renewable technologies to existing centralised energy infrastructures. But it also instantiates creative and successful problem solving in the face of such challenges. According to Watts, these encounters with hydrogen technology

[194] Fig. 54 appendix

[195] "SIEI – Stuart Island Energy Initiative," n.d., accessed April 24, 2021, https://www.siei.org/.

[196] Laura Watts, *Energy at the End of the World: An Orkney Islands Saga* (MIT Press, 2019).

emphasise the efficacy of *future-making* as a situated and place-specific practice. [197]

A Hydrogen Ecology

> *We must stop burning up the house to keep the family warm. We have all the technology needed to tap vast cosmic energies of the sun, but greedy big business and money drunk government won't allow it because they haven't found a way to place a meter on the sun.* [198]

Despite recent advances and policy developments, the hydrogen economy is far from achieving its potential integration into energy infrastructures. It is still referred to as the energy paradise of the future –often heard in the Electrochemical Innovation Laboratory, in talks and public engagement events. Is this failure to fulfil its promise and defer to fossil fuel extraction, situated within and aligned with the broader collapse of utopian narratives of the 20th century? This is perhaps a register of the Anthropocene's temporality, of a future and its utopian landscape already assigned as past event. In the capitalist 'ruins' of the Anthropocene, the idea of a hydrogen *economy* is perhaps self-abnegating – can finance organise itself around an energy vector derived from water? [199]

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[197] Veera Kinnunen and Jarno Valkonen, "Laura Watts (2018) Energy at the End of the World. An Orkney Islands Saga. Cambridge and London: The MIT Press. 440 Pages. ISBN 978-0262038898," *Science & Technology Studies* 32, no. 4 (October 28, 2019): 175–177.

[198] Richard Buckminster Fuller and Jaime Snyder, *Operating Manual for Spaceship Earth*, New ed. (Baden: Müller, 2013).

[199] Besides the disincentives of hydrogen previously discussed, the problematic notion for the energy industry of water as a non-extractive resource for hydrogen production cannot be ignored. Should water become an important industrial resource for hydrogen production, how would this impact its 'value' or commodification?

Definition of ecology:
1: a branch of science concerned with the interrelationship of organisms and their environments
2: the totality or pattern of relations between organisms and their environment
3: HUMAN ECOLOGY
4: ENVIRONMENT, CLIMATE
// the moral ecology
also: an often delicate or intricate system or complex
// the ecology of language [200]

If the 'hydrogen paradise' was indeed annexed by fossil fuel capitalism, it is difficult to predict if we will ever see an economic energy grid based on hydrogen that might fully displace an oil economy, this however does nothing to deny its potential and value under different metrics. Making the conceptual shift towards an *ecology* of hydrogen precipitates a rethinking of its relationships and uses. Self-built, low cost, and small-scale renewable hydrogen systems can supply gas that can be used in many similar ways as liquid petroleum gas or natural gas.

Solar hydrogen's potential is not a panacea, a magic bullet in terms of solving the complexity of human causes of climate change and damage to the planet - as Bookchin points out, technology alone will not solve the urgencies of the Anthropocene - but if it did find use as a primary global fuel and energy carrier in transport systems, domestic heating and cooking, and industrial processes, the planet would see significant reductions in carbon dioxide emissions and air toxicity.

With the aim of developing renewable hydrogen installations for participatory engagement or usership I set out the following criteria for a *hydrogen ecology* in my practice:

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[200] "Definition of 'ecology' accessed March 30, 2021, https://www.merriam-webster.com/dictionary/ecology.

- Social matrix - community of usership
- Distilled water (free of contaminants) – solar still
- Renewable electricity – photovoltaic cells/wind turbine
- Electrolyser - alkaline electrolysis – stainless steel plates, rubber gaskets, gas separation membranes, potassium hydroxide or Sodium hydroxide
- Gas storage – bladder tank
- Hydrogen output – applications – cooking, heating, vehicle engines and generators, welding, fuel cells.
- Oxygen Output – World Health Organization essential medicine, and hydroponic systems nutrient solution oxygenator

This project investigates the making and use of hydrogen – 'the lightest and most abundant element in the universe' [201] – apropos to Arte Útil; as utilitarian artwork for participatory usership. It hypothesises the democratisation of hydrogen and examines the feasibility of building an electrolyser as economically as possible using basic technical skills and materials normally attributed to a workshop technician. [202] Due to their prohibitive cost, I have

[201] Hydrogen Power - Science Fact or Science Fiction?' By Patrick Armstrong | Borderlands [Vol. 52, No. 4, Fourth Quarter 1996]," accessed March 30, 2021, https://borderlandsciences.org/journal/vol/52/n04/Armstrong_on_Hydrogen_ Power.html.

[202] Whereas industrial electrolysers and fuel cells require expensive materials for electrode material, I have found that 316L stainless steel provides a low-cost alternative for this project. Silk screen printing mesh may also offer a low-cost solution as a gas separation membrane for electrolysis.

avoided working with fuel cells in this project and instead look for alternative uses for hydrogen. [203]

During my 2015 three-month residency at EARTH University in Costa Rica. I studied biodigesters for methane gas production and gained insights into how renewable technologies can be simplified and made accessible. Collaboration with the Department of Renewable Energy at EARTH University highlighted the value and potential of integrating these ideas into a programme of practice-based investigation through a series of installations and workshops.

The opportunity to collaborate with the Electrochemical Innovation Laboratory (EIL) at UCL with the support of Dan Brett, professor of electrochemical engineering, as a secondary supervisor, has provided me with invaluable access to specialist knowledge and expert guidance in the construction and testing of hydrogen electrolysers. In this context of advanced academic research into chemical energy systems, my aim was to follow a revisionist [204] approach, repurposing established technology and techniques from the last century, concentrating on reviving obsolete systems where functionality and longevity had been proven and may find new utility by being inexpensively re-invented. [205] As the first example of a visual artist researcher partnering with the EIL in the department of chemical engineering at UCL, working alongside researchers from a scientific field, successful outcomes would be in part defined by the efficacy of this interdisciplinary practice across art and science.

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[203] Hydrogen fuel cell technologies in public transport and other vehicles, even bicycles, still depend on a centralised production of blue or grey hydrogen.

[204] See note 13.

4. Descriptive Account of Research

4.1 Water Gas Car

Figure 19. *Water Gas Car*, 2016, MP4 video, 2:31 mins, video still, camera Elisabeth Laessing

The *Water Gas Car* project began before this research project in 2012 after meeting engineer and fabricator Jimmy Whitmore who I worked with on an outdoor sculpture commission. We discovered a shared interest in the story of Stanley Meyer (1940-1998), an inventor from the US who claimed to have developed a vehicle powered by water; its only emissions being water vapour. Meyer claimed to have discovered a previously unheard of means of splitting water by electrolysis into hydrogen and oxygen so efficiently that it could be achieved on-demand, as the car was driving and without the need for added batteries or other energy sources. The mixture of hydrogen and oxygen gas fuelled a conventional car engine. Video footage (now viewable online) from local TV news networks during the 1990s show Meyer interviewed and driving his car on public roads. In 1998 after attending a meeting with a potential investor in a restaurant near his home, Meyer collapsed and died suddenly in the restaurant car park. The circumstances of his death as well as numerous unsuccessful attempts by others to replicate his work generated a conspiracy theory that claimed his invention was suppressed at the expense

of his life. Scientists cannot verify Meyer's invention, but this has not deterred Meyer's enthusiasts from experimenting with his ideas. Some say that his patents and notes contained deliberate mistakes to protect his ideas falling into the wrong hands. His water car was purchased and mechanics with support of an online forum attempted to back-engineer his technology, without success.

Figure 20. B Car. Burden, Chris & Alexis Smith. Los Angeles, CHOKE Publications, 1977.
2021. Pinimg.com. 2021. https://i.pinimg.com/originals/0c/39/10/0c3910fd7eee6f200e9f12bed96a232f.jpg.

Another influence for this project was Chris Burden's 1977 B-Car, designed to travel 100 mph and achieve 100 miles per gallon (fig. 20). Burden described the car as the most 'elaborate fantasy of his life.' [206] In response to the fuel shortages of the 1970s, his B-car had to be low cost and light weight; it was powered by a small motorcycle engine. How would this fantasy apply

[206] Chris Burden and Alexis Smith, *B-CAR: THE STORY OF CHRIS BURDEN'S BICYCLE CAR* (CHOKE Publications, Los Angeles, 1977).

to the current urgent conditions of ecological emergency? I aimed to take an old car and run it without fossil fuel.

These stories initiated this collaborative project that aimed to replicate Meyer's work and make a car run on water as he had claimed. After initially funding the first stage of the project through the Laurenz Haus Stiftung residency in Basel, together with my own funds, it was hoped that we might get the support of art institutions to develop the work and exhibit the car in progress as it developed, thereby extending the collaborative process into an institutional context. After starting experiments in Basel, the car was first developed in Amsterdam. Since then we have used Jimmy's workshop in Devon for recent stages of work (fig. 21).

Our test car was a 1988 white VW Golf GTI MK2. It seemed appropriate to use this car, partly out of convenience as it had previously belonged to Jimmy and the white paintwork seemed to fit well with the colourless gas that would be its fuel. Mechanics considers this generation of cars to be straightforward to maintain and service. Parts were also affordable and easily found second-hand.

The technical challenge of the project depended on using the electrochemical process of electrolysis to split water into hydrogen and oxygen very efficiently. Electrolysis normally would require substantial electrical input to maintain the ongoing reaction of decomposing water into hydrogen-oxygen gas. Stanley Meyer claimed he had found a novel and highly efficient way to achieve this and injected the mixed oxygen and hydrogen gases into a conventional car engine. We hoped to find a way to follow this process.

While building and testing our first oxyhydrogen electrolyser which was installed in the boot of the car with a hose connected to the engine, we conducted many experiments and not unexpectedly experienced many setbacks. We discovered that mixing this gas with petrol and driving the car

gave positive results. Adding oxyhydrogen gas to the petrol at the air filter intake of the engine, resulted in increased fuel economy and fewer harmful emissions in the exhaust gases when we were driving.

Figure 21. *Water Gas Car* Workshop fabrication using polyester silk screen printing fabric for gas separation membranes, Nick Laessing (top), Jimmy Whitmore (left) and Jonah Kinross (right), Devon, photo Nick Laessing, Jonah Kinross.

Without access to lab testing equipment or specialist scientific instruments our research and results were based on deduction through observations, following tacit understanding and hunches. For example, when hydrogen-oxygen gas was added to the engine (also burning petrol), the odour of the exhaust emissions became less unpleasant and poisonous. We also saw vapour condense at the exhaust and make small puddles on the floor, which we reasoned by taste was water. Later, looking at scientific studies[207] I discovered that these observations were supported by academic papers stating that the addition of small amounts of hydrogen to petrol causes a higher ignition temperature in internal combustion engines by burning closer to 100% of the petrol at ignition which in turn causes improved emission gases.

During the first stages of the work, we managed to run the car engine at idle using pure oxyhydrogen gas without petrol. However, the electrical power demand was so great that it was not possible to supply enough electricity to the electrolyser to provide sufficient gas to drive the car for longer periods or at speed. Large, powerful car batteries would run down in just a few minutes.

And yet we had managed to run a car engine on water, even if it was only at idle and for short bursts of under a minute which nevertheless felt like a breakthrough and made us hopeful. Could it be possible that a more efficient system would be more successful? We did what we could to improve the electrolyser by redesigning and rebuilding it, adding an additional alternator into the car engine bay to improve battery charging. Unfortunately, these efforts proved unsuccessful.

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[207] See 1977 Nasa study, Engine running on gasoline and a hydrogen-gasoline mixture. Cassidy J. Emissions and total energy consumption of a multicyliner piston engine running on gasoline and a hydrogen-gasoline mixture.
"NASA Technical Reports Server (NTRS)," accessed May 4, 2021, https://ntrs.nasa.gov/citations/19770016170.

The car was first exhibited at Gowen Contemporary Gallery in Geneva in 2013, and in the same year in the group show Aqua Vitalis, Positions de l'Art Contemporain, Artothèque de Caen, France, then in 2016-2017 in the group show No Such Thing As Gravity at FACT in Liverpool. In the weeks prior to each exhibition using the institution's funding to pay for materials and parts we attempted to test out various improvements continuing from where we left off and then to drive the car to the institution.

In the first weeks of this PhD research further adaptations were made to produce pure hydrogen rather than oxyhydrogen for the car, for the exhibition in 2016 at FACT, Liverpool.

Direct electrolysis of water splits water molecule into oxyhydrogen - a raw mixture of hydrogen and oxygen (known in German as Knallgas, which translates as bang-gas), which being volatile and highly combustible is unsafe to store or pressurise. Written accounts of early experiments with oxyhydrogen and its use in stage lighting and streetlamps, recount accidents and fires. It must be burned as it is produced – this works well in certain small-scale cases such as for jewellery welding that require a low gas and heat output.

As the oxygen and hydrogen gases bubble off the electrode plates they can be kept apart by a membrane, channelled out of the electrolyser and then stored safely and burned as needed. Searching online forums, I discovered one or two examples of this by hydrogen hobbyist engineers who had built their own electrolysers, comparable in design to the first industrial electrolyser systems. They used various kinds of materials to separate the gases as they left the electrode. This ranged from kitchen dish cloths to fine mesh screen printing

fabric.[208] Industrial applications traditionally used asbestos sheets for this purpose. Emulating these systems, I developed the design to channel the separate gases out of the system. This used a high mesh-count polyester screen-printing fabric to separate the gases between the electrodes.[209] Variations of the filter press electrolyser have been in use since the late 19th century (fig. 18, 22), though few examples exist today.

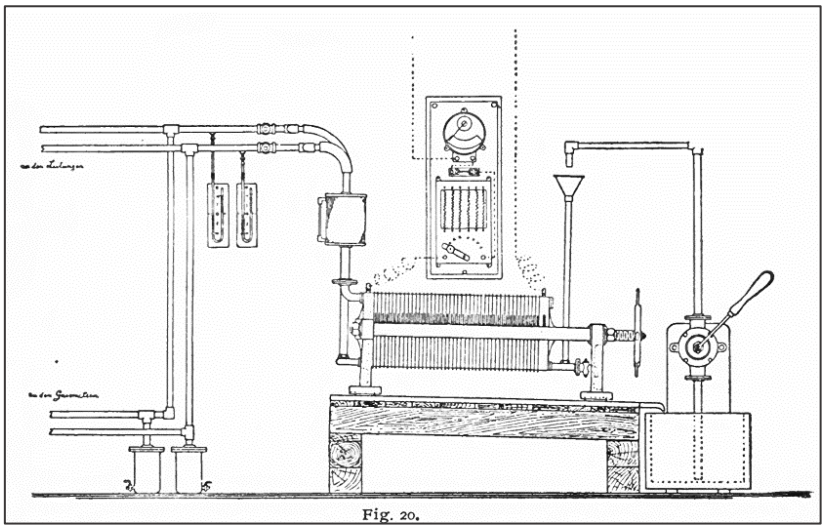

Figure 22. Schmidt Filter Press Electrolyser, 1899, The Electrolysis of Water, Processes and Applications, Engelhardt, V. Chemical Publishing Company, 1904

With the gases separated the hydrogen could be safely stored. We made tests by sealing plastic refuse sacks with vinyl tape and filling them with hydrogen from the car's electrolyser. Now we could see the engine running on our homemade pure hydrogen. The exhaust pipe dripped, and large puddles of water appeared on the ground. Since now we were separating the gases, this

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[208] "Hydrogen Generator - Page 4 - RC Groups," accessed March 30, 2021, https://www.rcgroups.com/forums/showthread.php?2537905-Hydrogen-Generator/page4.
Hydrogen Generator, Solar Power, Steam Engines and Much More The DIY Science Guy Trailer., n.d., accessed March 30, 2021, https://www.youtube.com/watch?v=x0oWf04e-4c.

system was a departure from the mythical invention attributed to Stanley Meyer. [210] Hydrogen could now be collected and stored for use in the engine while the oxygen vented off into the atmosphere; the addition of solar panels supplied power to produce the gas, substituting the need for heavy and expensive batteries. The car engine now ran well on the gas. The silk screen mesh separator membrane clearly produced a purer hydrogen gas. A pure hydrogen flame burns almost invisibly but with the water vapour the flame had a yellow-blue colour when we made flame tests. It burned like a candle flame but without the black soot carbon residue, very differently to the volatile hissing of the oxyhydrogen flame. Holding a metal plate above the flame, it was possible to see water droplets forming on the surface.

We then needed a means of storing the gas. A local tarpaulin company fabricated a reinforced PVC bag that could be attached to the roof of the car. This emulated the gas bag cars of the 1930s and 1940s that used coal gas to run vehicles during fuel shortages. [211] During my residency at Earth University in 2015 I learned how methane gas was stored in enormous rubber bags or bladders on the university campus. Since hydrogen airships followed this principle, it seemed possible that this could also work on a smaller scale for our purposes. As the smallest atom, hydrogen might prove more permeable than methane and prone to leak, but I reasoned that if stored outside at a safe distance and carefully monitored any risks could be avoided during initial testing.

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[210] Direct electrolysis of water splits the water molecule into a raw mixture of hydrogen and oxygen, which due to the oxygen is volatile and highly combustible and so unsafe to store, therefore it must be burned as it is produced. However, once the gases are separated then hydrogen in its pure state can be stored safely and burned when required. This required me to develop a different design of the electrolyser to channel the separate gases out of the system.

[211] Fig. 58 appendix.

A thick plastic dust extraction hose was installed to direct the gas from the bag through a hole in the bonnet and into the engine's carburettor. Ten solar panels set out around the car would power the electrolyser which was installed in the boot. The reinforced PVC bag (approximately three cubic meters), lashed with bungee cord to a steel frame on the roof of the car would inflate. We calculated it would take about two days to fill the gas bag using the sun's energy and once full the car would drive approximately 12 miles. [212]

It was only many months later, preparing a slide show, that I noticed a striking comparison in this work with Gustav Metzger's work *Mobbile,* 2015. A transparent box sits on the roof of a white car with a plant inside it. A thick hose connects the box to the car exhaust and the plant is suffocated, turning brown as the car runs and exhaust fumes enter the box. The hose evokes the hose of the hydrogen gas bag as it connects to the engine of the Golf. [213]

Figure 23. *Water Gas Car* at FACT Liverpool, photo Nick Laessing

[212] One gallon of petrol is equivalent to approximately 10 cubic meters or 1kg of hydrogen at atmospheric pressure. Universal Industrial Gases, Inc. Hydrogen Unit Conversion (gas, liquid) [Internet]. Uigi.com. 2018 [cited 13 February 2018]. Available from: http://www.uigi.com/h2_conv.html.

[213] Fig. 59, 60, appendix.

Water Gas Car and Usership

During the various stages of working on the car in the Devon workshop, several people volunteered with valuable advice and practical help, including family, friends and mechanics from neighbouring workshops, all to varying degrees motivated by their interest in the project. These informal collaborations sparked conversations about the purpose of the project, the aims behind it and the consequences of running a car on water – 'what would happen if we all did it?' The keen sense of excitement in our small group during the first tests running the car with our home-made hydrogen, seemed like a breakthrough, a eureka moment for us all; we had achieved something unusual and transformative together - the idea of being able to transform a thirty-year old, polluting petrol car [214] into a zero-emission vehicle suddenly seemed very real and achievable. The project, founded on artistic thinking and shared idealism, but embedded in technical challenges and hard work, allowed us to test the intersections and limits where imagination, technical ability and limited resources can meet through collaborative efforts of individuals working together from multidisciplinary backgrounds.

After many experiments we discovered that we could make our own hydrogen gas and run a conventional car engine using simple modifications and off-the-shelf and repurposed parts, including an LPG (liquid petroleum gas) conversion kit that was bought for under £200. Installing the electrolyser into the car meant that it was theoretically possible to make 'fuel' as needed – if water was available. This car, with its absurd and impractical roof top gas bag and low mileage range nevertheless would run on a homemade non-polluting fuel. Further adaptations, for example compressing the gas into steel or carbon fibre tanks would allow a mileage range closer to fossil fuel vehicles.

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[214] 'Petrol fuel pollutants include carbon monoxide, oxides of nitrogen, un-burnt hydrocarbons and particulate matter. Cars and air pollution [Internet]. Dft.gov.uk. 2018 [cited 6 February 2018]. Available from: http://www.dft.gov.uk/vca/fcb/cars-and-air-pollution.asp

Up to this point we had been collecting small volumes of gas for testing the car engine; we now decided that without being able to precisely test the hydrogen and oxygen concentrations in the gas we were making we could not be sure of its purity - we needed to achieve at least 99% H2 for safe gas storage. It would not be safe to fill the three cubic meter roof top gas bag. [215] And yet it still felt important to tell the story of this elaborate fantasy - even though at this stage, driving the car for longer distances remained a fantasy.

In the resulting short video work, I was filmed setting out the solar panels around the car and plugging in the electrolyser. Gas bubbles up in the filler tanks, the gas bag appears to gradually fill and bulge with gas. Once the bag has inflated, I load up the panels, start the engine and drive off into the narrow the lanes of the Devon countryside. The two-and-a-half-minute video work was exhibited as part of the installation work *Water Gas Car* for the exhibition at FACT.

Unlike the Golf petrol engine, designed to produce its own hydrogen, the EIL's Toyota Mirai relies on filling stations. It stores hydrogen at high pressure in carbon fibre tanks which connect to a fuel cell, transforming hydrogen into electricity which powers an electric motor. This almost silent car with its impressive 300-mile range comes at a cost of 64000 Euro. Filling up the Mirai costs £47; most hydrogen filling stations currently supply grey or blue hydrogen derived from fossil fuels. There are currently thirteen hydrogen filling stations in the UK. [216]

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[215] After returning to UCL and testing the electrolyser, it was proven to be the right decision, see next section on *Hydrogen Kitchen.*

[216] "Where Can I Buy Hydrogen and Where Is My Nearest Hydrogen Filling Station?," *DrivingElectric*, accessed April 6, 2021, https://www.drivingelectric.com/your-questions-answered/1363/where-can-i-buy-hydrogen-and-where-my-nearest-hydrogen-filling-station.

We paid just under £1000 on eBay for our thirty-year-old VW Golf. The materials for our electrolyser and other parts amounted to £1600, not accounting for the two to three weeks of time spent on fabrication and adapting the car.[217] The Golf, with its inbuilt electrolyser requires only purified water, which can be cheaply bought or purified from tap or rainwater using a distiller. Does it make any sense to compare an expensive production vehicle, the result of thirty years of research and development, with the results of a three-person collaboration reviving obsolete technology with a tiny budget over a few weeks? Perhaps only to suggest that in the pursuit of clean energy technology, the direction and pace of industrial production may be out of step with the kind of radical and transformative adaptations that could offer responses equal to the urgencies of planetary ecological crisis. If we could achieve our own albeit ad hoc transformative technology that resulted in a car running on water in just a few weeks of effort, what might be possible with greater resources, let alone those of a global car corporation?

[217] See fig. 62 appendix for details of electrolyser costs.

4.2 Hydrogen Kitchen

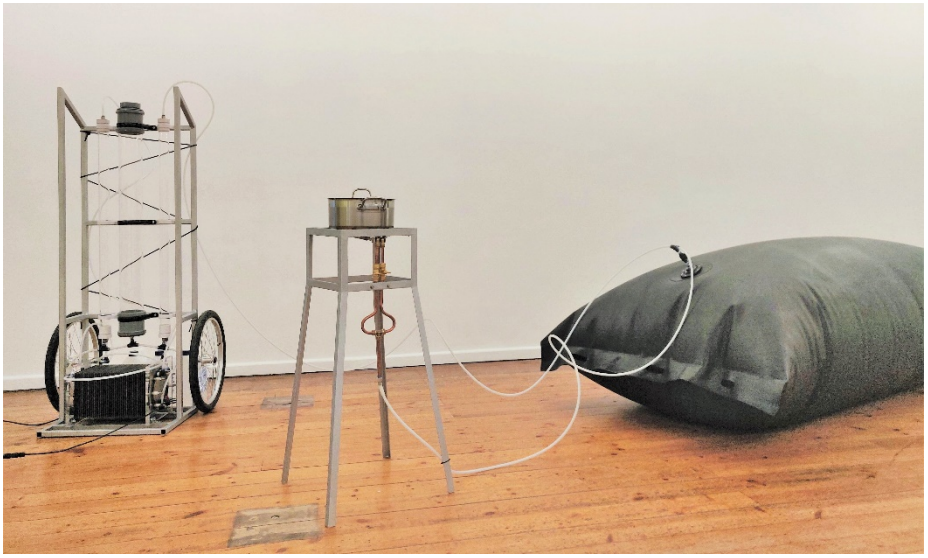

Figure 24. *Hydrogen Kitchen* Installation, Experimental Futures, Rostock Kunsthalle Germany 2019, photo Nick Laessing

Following the *Water Gas Car* project in Devon, *Hydrogen Kitchen* was made at UCL working between the Slade PhD studios, the Institute of Making, the Slade sculpture workshop, and the Electrochemical Innovation Laboratory in the Department of Chemical Engineering.

The aims for this art installation were:

- To build a solar hydrogen cooker with gas storage, for everyday usership.
- To improve the electrolyser design to achieve gas concentration of minimum 99% H2, achieving the industry standard safety threshold, while keeping the basic principles of the assembly which seemed to work well. I aimed to do this by focusing on gasket design and gas separation membranes. Partnering with the Electrochemical Innovation Laboratory, I would be able to precisely measure gas output and receive advice and support with the electrolyser fabrication.

- To design a low-cost safe gas storage system so the stove could be used outside the hours of sunshine and daylight. The electrolyser was solar powered so required a storage system to allow for cooking during the day or night.
- To design and fabricate a cooking stove that could safely burn hydrogen for contexts of usership and participatory events.
- To mount the electrolyser on a portable frame

Figure 25. Two-plate electrolyser, photo Nick Laessing

The basic principles of a filter press electrolyser are relatively simple and can be designed around the available supply of electrical energy in volts and amps. This could be the output of a battery, a wind turbine, or a bank of solar panels. The theoretical laws of water electrolysis require 1.23 volts of direct current between two electrodes for the decomposition of water. In practice

other factors influence this, including temperature, distance between electrodes, quality and concentration of electrolyte and electrode material. I have found that just under 2 volts between electrodes is about right for best output without over potential or overheating. The number of electrode plates is defined by available voltage. For example, a 12 volt supply would require 6 electrode pairs (of 2 volts each) and a total of 7 electrode plates. The surface area of each electrode plate is defined by available amps. The larger the surface area, the more amps it can tolerate before overheating and degrading.

I designed the electrolyser for higher voltage and lower currant to make the wiring as simple as possible and reduce resistance in all cable connections. 61 electrodes plates would create 60 electrode pairs of 2 volts each across the stack. A single positive and negative 120VDC connection at each end of the cell (from the solar panels wired in series) would transfer power across the stack at maximum 8 amps. Electrolyser literature describes this as a bipolar configuration.

I calculated that the surface area of the electrodes would produce an approximate output of 4.6 litres of hydrogen and 2.3 litres of Oxygen per minute. The added advantage of this 120-volt DC system meant the electrolyser could also be powered by 240VAC household wall socket via an adapted 110VAC building site transformer which I converted to output direct current. The electrolyser could be plugged into a wall socket and demonstrated at locations where it was not possible to store the gas – for example during my residency at Delfina Foundation.

Aiming to improve the previous design that was used in the car, I made a small 2-volt low output electrolyser that could be easily carried between my studio and the EIL for experimenting with gasket design and membrane material. It would also fit into the fume hood of the EIL mass spectrometer and supplied just enough gas output for testing. EIL PhD students Max Maier, James Dodwell and lecturer Rhod Jervis were generous with their time in

helping me with the spectrometer testing and incredibly supportive with general advice on the electrolyser construction (fig. 26).

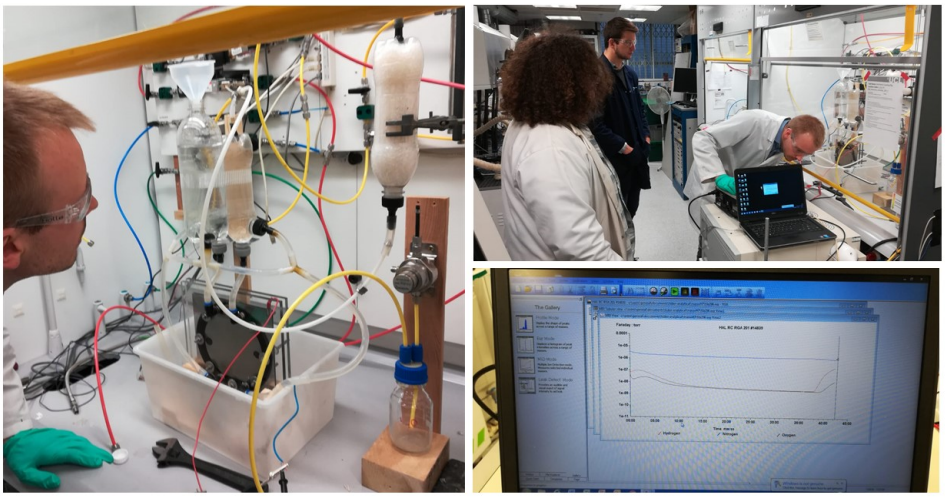

Figure 26. Using the mass spectrometer with Rhod Jervis, James Dodwell and Max Maier at the EIL, photo Nick Laessing

After researching the latest industry standard gas membranes and experimenting with the shapes of the gaskets I found that replacing the polyester screen-printing mesh with Zirfon Perl, an industrial gas separation membrane and changing the design of the rubber gaskets significantly improved the quality of the gas (fig. 27, 28).

Repeatedly running tests and each time opening the electrolyser to look inside, stains were visible on the Zirfon and stainless-steel electrodes from the electrolyte (water and potassium hydroxide). This helpfully revealed unwanted leaks and areas of the gasket to redesign. In addition, adding pieces of cutting knife blades provided more support to the assembly, preventing leakage and mixing of the gases.

Figure 27. Zirfon Perl, photo Nick Laessing

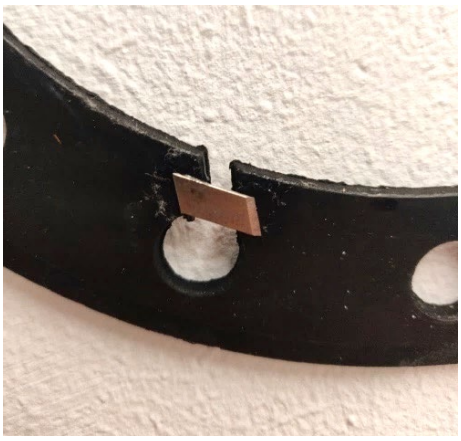

Figure 28. Gasket detail with cutter blade, photo Nick Laessing

Small amounts of potassium hydroxide or KOH were added to pure water to make the alkaline electrolyte that is required for this system. This completes the 'circuit' in the electrolyser, allowing current to pass through the water. Adding too much would increase current flow and risk overheating and harming the electrodes. Adding too little would reduce H2 output. In the large electrolyser the white powdery flakes of KOH would be added by the teaspoon until current reached 10 amps and the voltage between the plates was about 2 volts. [218]

I had planned to cut down the 200x200x1mm stainless-steel electrode plates to the size of the circular gasket diameter, to reduce the weight and volume of the electrolyser, but a test revealed that the electrolyte would more readily overheat. The extended plates acted as a heat sink, convecting heat out of the electrolyte. I had seen other electrolysers online that solved this using a

[218] Most literature on alkaline electrolysis advises a 30% KOH solution. In my experience, this depends on the distance between electrodes which in this system is being a compromise. There must be enough space to allow for electrolyte flow and the escape of gas bubbles. I found it possible to use a lot less KOH than 30% even with 6mm (two 3mm gaskets) between the electrodes.

plumbed in pump and radiator. The extended plates offered a simpler solution to this problem (fig. 31).

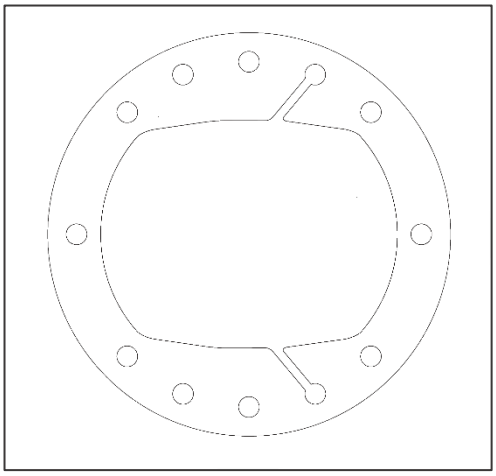

Figure 29. Gasket drawing for laser cutter, Nick Laessing

Figure 30. Oxygen analyser, photo Nick Laessing

The gaskets and Zircon membranes were drawn using Adobe Illustrator software and cut using the Institute of Making laser cutter (fig. 29). I used 3mm EPDM rubber. Narrowing the electrolyte channels on the electrolyser gaskets improved support and strength when bolted together. This further improved the gas quality.

Searching online for affordable ways to monitor the gas concentrations on the larger electrolyser when outside the laboratory, I discovered that a hobby-engineer had built his own hydrogen electrolyser to fill a model blimp. [219] He used a diving equipment oxygen analyser to measure gas quality. [220] Since the only other gas in this system is oxygen, this seemed like a promising idea,

[219] "Hydrogen Generator - MakerGear Forum," accessed March 30, 2021, http://forum.makergear.com/viewtopic.php?t=3162.

[220] The hobbyist engineer used screen printing mesh for gas separation, and claimed good results.

and I purchased a Greiseinger GOX 100 oxygen analyser for £200 which when tested against the EIL mass spectrometer proved sufficiently accurate (fig. 30). A hydrogen detector alarm borrowed from EIL would sense concentrations of H2 in the air and warn of leaks.

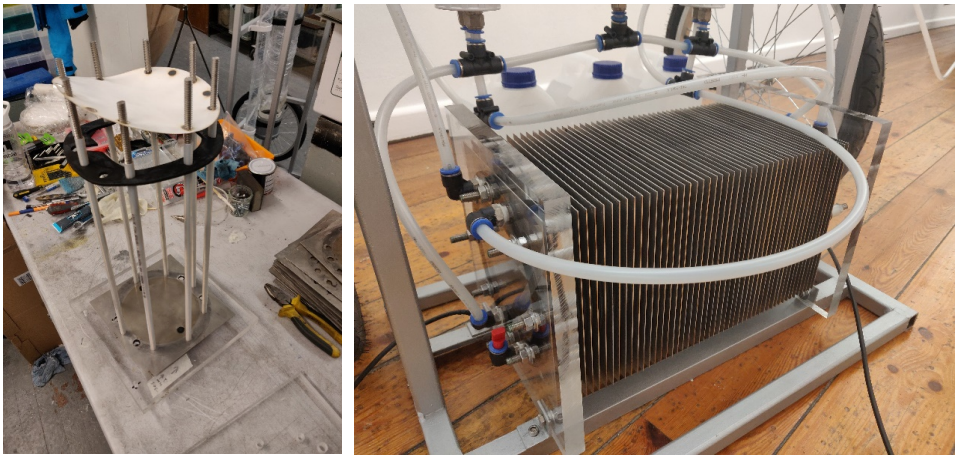

Figure 31. Assembling the electrolyser in the Slade PhD studio and detail of assembled electrolyser, photo Nick Laessing

Following my experiments and the use of Zircon membrane in the redesign, the electrolyser assembly would now consistently achieve the required gas concentrations of over 99% H2 (fig. 30). Now it would be possible to store the gas.

Gas Storage

As previously discussed, biogas systems (or anaerobic biodigesters) that produce methane from food and animal waste commonly use flexible storage tanks made from plastics or rubber materials. Given concentrations are checked and remained safe at over 97% pure hydrogen gas in air and 99% pure gas in oxygen environments, storing hydrogen in a 'bladder' although unconventional ought to be possible and I planned to test this with the newly constructed electrolyser using a butyl rubber gas bag made for methane gas storage by the company Butek Landline in Essex (fig. 32). The three cubic metre bag has been exhibited as part of the installation *Hydrogen Kitchen*, but unfortunately it is still to be tested due to the Covid-19 pandemic lockdown.

Figure 32. Hydrogen stove and butyl rubber gas bag, photo Nick Laessing

Hydrogen Gas Stove

In 2018 I presented my work at Petrocultures, a conference exploring the impacts of fossil fuels on culture and the humanities, hosted by the University of Glasgow. I met another presenter, Dr Charlie Dunnill, founder of the Dunnill Research Group, focussed on sustainable hydrogen innovation and technology at Swansea University. I was fascinated to learn of his research into renewable hydrogen and even more so that he had built a wind powered electrolyser and hydrogen BBQ in his garden in Swansea. I later visited Charlie and he gave me a tour of his university research workshop and hydrogen BBQ in his garden at home.[221] I learned that he had successfully experimented with a rubber gas bag for hydrogen storage and that he was also working with alkaline electrolysis. Charlie's academic research is focused on real world results; his research group aims to scale up hydrogen technology

[221] Fig. 64, appendix

with industry and government partnerships. He also designed, a pedal powered hydrogen generator for public engagement activities. [222]

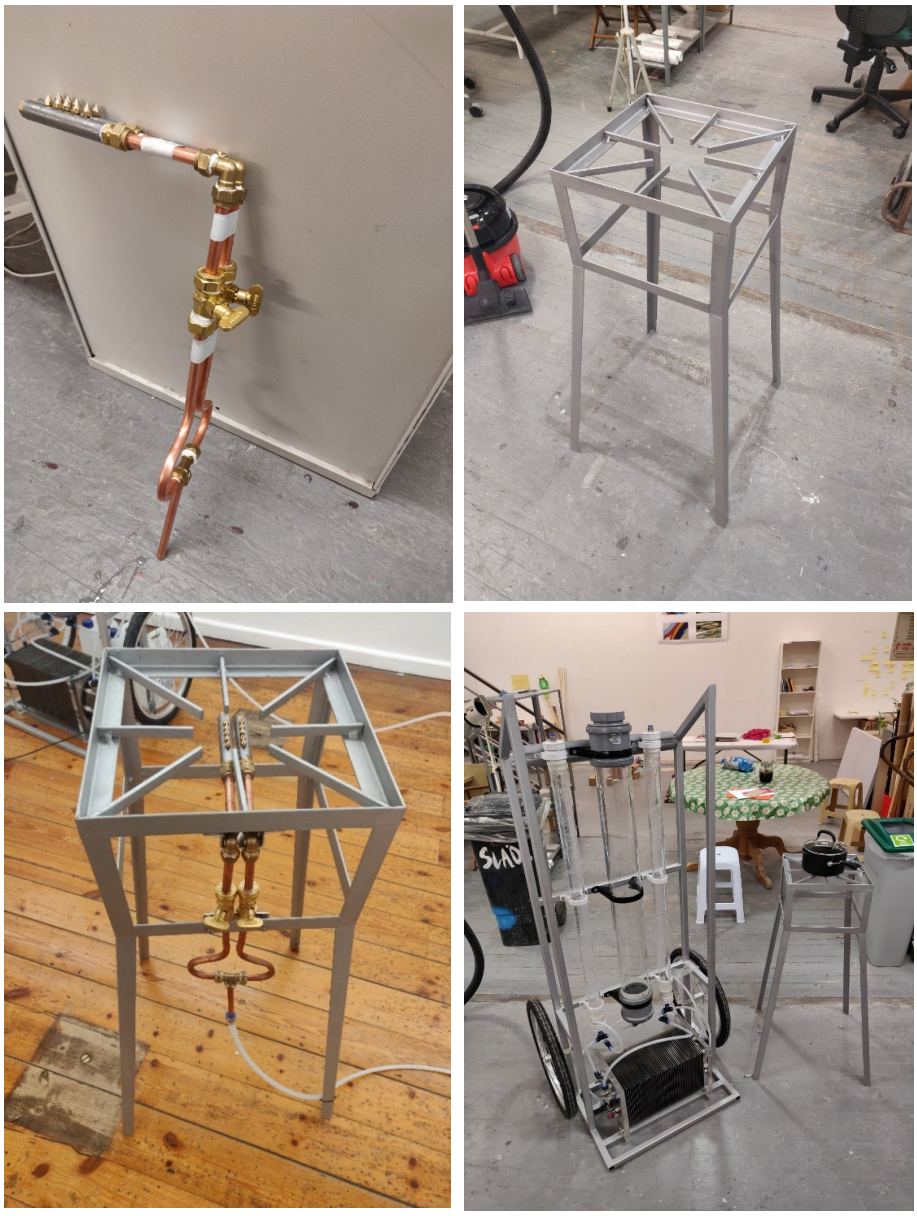

Figure 33. Views of hydrogen gas stove and electrolyser cart in Slade studio, photo Nick Laessing

[222] Fig. 65, appendix

Charlie offered helpful advice on the construction of a hydrogen gas stove. He advised using tiny gas burner ports (under 0.5mm) for the stove rather than adapting a conventional natural gas or camping stove. This supported the one document I had found on building such a stove. *Hydrogen Chronicles* [223] recommends about 0.5mm holes to quench the flame, preventing it travelling back down the pipe if gas pressure is reduced.

To avoid the difficulty of drilling tiny holes, I found and ordered 0.4mm 3D printer brass extruder nozzles that could be screwed into larger holes in steel tubing (fig. 34). After testing, I estimated that 10 nozzles should allow for the four litres per minute gas output of the electrolyser and provide sufficient gas output for a cooking pan. This could also be adjusted using two valves. I plumbed this into a 10 mm copper pipe using standard gas rated brass fittings and mounted it to the welded mild steel frame.

Using mild steel, I welded and painted a portable frame for the electrolyser in the Slade sculpture workshop. The frame would support the electrolyser, two gas bubbler tanks and the centre fill tank, and protect them during transport. I could also easily attach other parts and instruments as needed to the frame, for example the oxygen analyser. Two small bicycle wheels support the weight of the electrolyser making it possible to push almost anywhere. The cart could also be adapted to pull as a trailer with my bike.

Running the electrolyser is straightforward; electrolyte – distilled or deionised water and a few teaspoons of KOH - is added to the central fill tank until the operating current reaches 8-10 amps, the positive and negative cables connect to the bank of solar panels. There are no switches or electronics,

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[223] This e-book has proven a valuable resource throughout out my work with hydrogen. It is based on a collection of articles by off-grid hydrogen enthusiasts that were originally published in Home Power magazine.
Walt Pyle, Solar Hydrogen Chronicles, A Hands-on Guide to Solar Hydrogen Fuel (Wheelock Mountain Publications, 2003).

although for safety purposes I added an emergency stop foot switch and the oxygen analyser. I used a multimeter clamp to measure current.[224] Gas bubbling up through the acrylic tanks indicates approximate rates of production. The oxygen is vented out.[225] The stove can be lit with a spark or a match as with a conventional gas cooker. A pure hydrogen gas flame is invisible, but the water vapour in the gas coloured the flame which was a helpful indication that it was lit.[226] [227]

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[224] A panel ammeter would have been preferable and will be added.

[225] The oxygen at this point is vented off but could find various uses within the ecological model of *Life- Systems* artworks, including oxygenating the feed tank water of *Plant Orbiter.* I had also considered an oxygen bar as an extension to *Hydrogen Kitchen.* Oxygen bars grew in popularity in the US in the 1990s but health benefits are disputed. I decided that I first need to further investigate their use and safety.

[226] If the gas is passed through a desiccant to dry it, or a ceramic flash back resister, the gas would burn invisibly. Hydrogen, being odourless and invisible can be difficult to detect in the case of leaks. Garlic odorants were mixed into the hydrogen gas that supplied German airships such as the Hindenburg, to aid detection of leaks. The crew were not permitted to eat garlic during passages.
Michael Freemantle2019-11-15T15:59:00+00:00, "Allicin," *Chemistry World*, accessed April 1, 2021, https://www.chemistryworld.com/podcasts/allicin/4010687.article.

[227] A patent also supported this observation. Wayne Ernest Conrad, "Method and Apparatus for Producing a Visible Hydrogen Flame," n.d.

Figure 35. Gas analyser showing 0.7% O2, or 99.3% H2. photo Nick Laessing

Figure 34. *Hydrogen Kitchen* gas flames using 3D printer nozzles for gas jets, photo Nick Laessing

Hydrogen Kitchen was conceived to produce hydrogen gas from solar power; to store the gas and use it for cooking as needed. The electrolyser can also be connected directly to the stove, without the use of the storage bag and can also be powered by a wall socket.

When the work was presented during my UK associate residency at Delfina Foundation in 2019, it was powered by the wall sockets due to a lack of outdoor space for the solar panels. Since the gas bag had not yet been tested, it was not used, instead on this occasion the electrolyser connected directly to the stove.

Hydrogen Kitchen and Usership

Hydrogen Kitchen was presented at the Delfina Foundation for two events during my residency. In November of 2019 I invited PhD tutors, colleagues and Delfina artists for an afternoon of pancake making with hydrogen (see fig.36). I briefly introduced the science of electrolysis and outlined the troubled history and lapsed expectations of hydrogen. Together we cooked buttery pancakes on the stove that were enjoyed with jam and maple syrup. The hydrogen gas flames produced plenty of heat; butter sizzled in the frying pan as the pancakes browned. As we used the cooker, it struck me that there was little apprehension about the usership of *Hydrogen Kitchen*; 'users' in fact seemed to engage positively with the technology. Are the claimed negative attitudes towards hydrogen over estimated? Incorporating the technology into daily domestic tasks such as cooking may well subvert the novelty and preconceptions of hydrogen.

Figure 36. *Hydrogen Kitchen* Installation Delfina Foundation London 2019, photo Nick Laessing

In December 2019 Delfina Foundation hosted the panel discussion Hydrogen Utopia? with invited speakers Chiara Ambrosio, (History and Philosophy of Science, UCL), Simon Ings (Culture Editor, New Scientist) and Rokiah Yaman (LEAP closed-loop technologies). As guests arrived, they were offered omelettes cooked on the stove with the help of Delfina staff and Andreea Ionascu (see fig. 37). Simon Ings then chaired a conversation with myself, Chiara and Rokiah, exploring art and ethics, sustainable practices and the 'usefulness' of art in precarious times, which opened up into a lively conversation with the audience.

Figure 37. Top: Andreea Ionascu cooking omelettes at Delfina Foundation for the event Hydrogen Utopia? Bottom: Delfina artists and guests, photo Ollie Harrop, Delfina Foundation

Figure 38. Arriving at The Calthorpe Project with the UCell fuel cell stack and a gas bottle of hydrogen, photo Nick Laessing

Hydrogen and community engagement

With the support of UCL Grand Challenges Doctoral Small Grants, that I applied for with Tom Heenan, I co-organised the event Hydrogen-Fuel of the Future? in 2018 at The Calthorpe Project in Kings Cross, in collaboration with UCell, (members of EIL's public engagement team) including Josh Bailey, Tom Heenan, Max Maier James Dodwell and Drasti Patel, in June 2018 (fig. 38). We presented a free of charge one-day workshop, inviting members of the public and the Calthorpe community (staff and volunteers). The event programme began with an introduction to the science behind hydrogen technologies, Josh Bailey introduced the UCell hydrogen powered 3KW fuel cell stack which we used to power a freezer to keep the delicious Calthorpe Cafe ice cream cool in the hot sun. Max Meier presented his own lab research as an example of a EIL research project. Younger visitors were fascinated by the UCell model solar-hydrogen cars. With help from James and Max, I demonstrated my research on the solar powered electrolysis *Hydrogen*

Kitchen, facilitating a workshop assembling an alkaline electrolyser with participants (fig 39). We scheduled time throughout the day for questions and group discussions with participants while enjoying the hydrogen-cooled drinks and ice cream. [228]

Figure 39. Hydrogen – Fuel of The Future? The Calthorpe Project 2018, photo Gyen Ming Angel

[228] For our write up on the event, see the UCell blog: https://ucellucl.com/2018/07/23/ucell-the-calthorpe-project-part-2/

The workshop, *Arte Útil (Useful Art): A Working Group* [229], was co-organised with Slade PhD colleagues Ellie Doney and Kasia Depta-Garapich with the support of an LAHP public engagement award in December 2018. Hosted by the Calthorpe Project, the event brought together students, academics, and community organisers for utility-based participatory investigations, to make, cook, eat and talk together. The three daily sessions took a different thematic and practical focus in addressing art and its relationship with utility, investigating recent developments in art theory and practice. In doing so we aimed to explore the overlaps of art, activism and community action, in response to current urgencies and in the context of artist Tania Bruguera's community engagement project and Turbine Hall installation at Tate Modern.

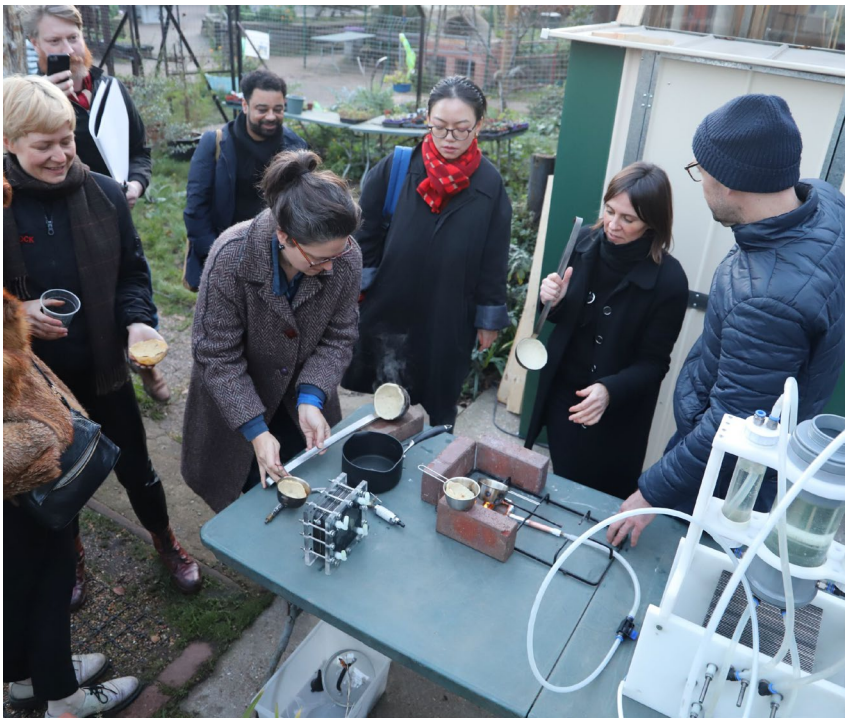

Figure 40. Arte Util/Useful Art Workshop, day two, making edible bowls with Kasia Depta-Garapich using a hydrogen flame, photo Adriana Arroyo

[229] https://www.lahp.ac.uk/arte-util-useful-art-a-working-group/

The first day began with bread and soup and introductions. This was followed by a tour of the community garden with Rokiah Yaman (director of LEAP Micro AD) and its living lab: a hydroponic plant growing experiment and anaerobic digestor that produces methane gas. I then presented my own research into home-made hydrogen, demonstrating my electrolyser producing a hydrogen flame (fig. 40). Retreating inside for the rest of the afternoon, and co-led by Dr Andrea Phillips (Professor, BALTIC Centre for Contemporary Art), we discussed Ursula K Le Guin's essay, 'A Non-Euclidean View of California as a Cold Place to Be' in the light of Useful Art and Tania Bruguera's *Tate Neighbours* project at Tate Modern. On day two during Kasia's presentation we used the hydrogen flame to grill bowls made from maize dough that we used for our lunch. On day three, led by Ellie and Calthorpe members we made tamales and artist Cedar Lewisohn gave a presentation of his collection of artists recipe books (fig. 41).

Figure 41. Arte Util/Useful Art Workshop, day three, making tamales, photo Adriana Arroyo.

4.3 Plant Orbiter

Figure 42 *Plant Orbiter,* 2017, 133 x 82 x 185 cm, installation Galerie PCP, Paris, photo Margot Montigny

The work *Plant Orbiter* extends the body of work, *Life-Systems* into an exploration of food production, reflecting on the role of hydroponics in local urban food cultivation and speculating on potential future scenarios of food scarcity. The work combines hydroponics with a rotary plant cultivation technology [230] and was exhibited in different contexts including Galerie PCP - a commercial gallery in Paris, The Calthorpe Project community garden and cafe, The Victoria and Albert Museum, Delfina Foundation, London and Newlyn Art Gallery, Cornwall.

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[230] The term hydroponics - the cultivation of plants using solution cultures as opposed to soil or earth planting - was coined in 1937 by William F. Gericke, a plant physiologist at The University of California. For an introduction to hydroponics see my essay in appendix, Plant Orbiter: Growing Plants in Micro Gravity, for the publication *Politics of Food* (appendix fig.70).

In the 1970s NASA (The National Aeronautics and Space Administration), predicting the need for food cultivation during long-term space travel and terraforming distant planets, began to investigate the possibility of growing plant food in zero gravity, extra-terrestrial environments. The conditions of zero gravity were imitated using variants of a clinostat, a scientific instrument designed to rotate plants and test their geotropic responses.[231] NASA's experiments led to a discovery that plant growth accelerates in an induced state of zero-gravity – under rotation. A patent titled 'Rotary Plant Growth Accelerating Apparatus' attributed to NASA in 1975 describes a device that combines this with hydroponics, claiming it to be:

> *…highly effective in increasing plant yields by removing the growing plants from the constraints of gravity…. not only is the rate of formation of carbohydrates by photosynthesis increased by gravity nullification, but the respiration rate is likewise increased when the plants are in the dark…* [232]

The patent states that plant yield is improved through this continuous rotation which negates gravitational force but does not further explain how this increases rates of photosynthesis. Had NASA, in researching extra-terrestrial plant cultivation inadvertently discovered a way to vastly improve plant cultivation on earth?

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[231] Plant geotropism (a plant's response to gravity stimulus) has been a source of continued scientific curiosity and investigation since the 1700s. In 1879 the botanist Julius von Sachs invented the clinostat. For more details see *Plant Orbiter* essay in *Politics of Food* publication, fig. 70 appendix.

[232] "Rotary Plant Growth Accelerating Apparatus," n.d., accessed April 6, 2021, https://patents.google.com/patent/US3882634A/en.
Appendic

Over the past three decades, additional patents and commercial products that combine rotary plant growing with hydroponics have appeared.[233] Many make similar claims– that plant rotation accelerates growth due to the disruption of gravitational forces which increases plant hormone production known as auxin. Cited results include quicker growth, bushier plants and greater yields than plants grown without rotation. Products such as the Omega Garden allege five times more yield than a typical hydroponic system.[234]

Rotary gardens also captured the interest of the marijuana growing community; commercial growers already skilled in hydroponics were attracted to the idea of maximising yields and accelerating harvests whilst optimising growing space. Online grow-forums host lengthy discussions about the technology - colloquially known as the 'Tunnel of Light' - with uploaded photos of self-built devices.[235]
Such anecdotal evidence is impressive, but I have been unable to find recent scientific research that supports it. These machines have found a place in scientific mythology, at least until more becomes known about the mysterious effects that are claimed for them.

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[233] Examples include the Volksgarden, the Omega Garden and the Quantum Leap device.

[234] 'Omega Garden discovered that if plants are continually rotated horizontally top to bottom these Auxins are evenly distributed throughout the plant aiding in plant growth and strength. The distribution of auxins due to plant rotation increases plant growth rates by several times that of a stationary plant assuming that all other factors are equal.' Lloyd Alter, "Omega Hydroponic Garden Gets Five Times as Much Food Per Watt," *Treehugger*, accessed April 6, 2021, https://www.treehugger.com/omega-hydroponic-garden-gets-five-times-as-much-food-per-watt-4856580

[235] Fig. 67, 68, appendix

Figure 43. *The Expanse* Jane, Thomas, et al. *The expanse. Season one Season one*. 2016.

Science fiction has long speculated on the importance of botanical practices and farming in future utopian and dystopian imaginaries, both for symbolic significance and as a necessity for extra-terrestrial human survival. Examples include novelists Octavia Butler (*Earthseed Series*), Margaret Atwood (*The Year of the Flood*), and Kim Stanley Robinson (*The Red Mars, Green Mars, Blue Mars* trilogy), and films such as *The Martian*, *Silent Running*. In the science fiction TV series *The Expanse*, a rotary garden can be seen in the crew's living area (fig. 43). Besides the utilitarian promise of this technology, its form evokes metaphorical associations – a constellation of plants orbiting around an artificial sun.

These open questions and imaginary relations prompted my own research into rotary gardens and led to the construction of two *Plant Orbiter* machines in 2017 and 2019, to test the claims made for the technology after researching the optimal parameters for building such a system. Research for this work was largely informed by online forums of the marijuana growing community, where expertise in hydroponics is openly shared. I also looked at expired patents and how existing commercial models could be improved both practically and visually.

Figure 44. Nick Laessing and Rodrigo Arteaga working in Slade Studio 2017, photo Anna Jochymek

Plant Orbiter 2017 was supported by Galerie PCP, Paris and was made in the Slade PhD studio (fig. 44). Art fabricator, Richard Simpson assisted with the design and created the CAD files for laser cutting the plexiglass and made the stainless-steel frame. [236] Slade MA student Rodrigo Arteaga assisted with the assembly and testing the hydroponics in the studio. Laser cut plexiglass parts were fabricated off-site by a plastics specialist and then assembled in the studio.

The plexiglass wheel holds five plants on each of its twenty-one lateral shelves, allowing for a total of 105 plants. I built a centrally positioned lamp using fourteen T5 lamps bolted around a tube of plexiglass. A nutrient-feed tank at the base of the wheel supplies nutrients and water to the plant roots, as the wheel turns the roots dip into the solution. Plant pots were made from acrylic tubing and packed with hydroponic rockwool growing medium. Four skateboard wheels support the wheel, one being driven by a stepper motor to rotate the wheel at about one revolution per hour.

[236] Fig. 66, appendix

Plexiglass is a material I have used in other works, including the electrolyser, but it is also a well-known petrochemical product, its manufacturing produces CO2 emissions. As a material it is durable, easily cleaned and nontoxic to edible plants or to the nutrient solution. I am drawn to its visual affect - evocative of scientific instruments and science fiction film imagery. As a transparent material used as part of a machine or technical system, it makes these technical processes visible. For example, the transparent water tanks of *Hydrogen Kitchen* make visible the hydrogen and oxygen gas bubbles. In *Plant Orbiter* the plexiglass reservoir and nutrient tank makes it possible to see the movement of nutrient solution as it is pumped into the upper tank each day.

The use of these materials provokes ethical questions of a practice concerned with sustainability and technology. Is the problematic impact of its fabrication offset by its broader and long-term benefits as an ongoing source of locally produced plant food? Such questions are pertinent to an art practice of the Anthropocene but also to industrial manufacturing. Organisations such as the Ellen MacArthur Foundation are addressing these issues by working with corporations to 'accelerate the transition to a circular economy' and in doing so aim to introduce new forms of cradle-to-cradle, zero waste production. [237]

After several weeks of testing in the Slade studio, the effectiveness of the system quickly became evident. The plants grew remarkably quickly in the wheel. Despite all the research that I had applied to the work, it was still surprising and fascinating to see plants thriving in such an environment. The

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[237] "Circular Economy - UK, USA, Europe, Asia & South America - The Ellen MacArthur Foundation," accessed April 24, 2021, https://www.ellenmacarthurfoundation.org/.
I am keen to find contexts where the work might be emulated using locally available repurposed and recycled materials as part of a collective or participatory project.

work was exhibited at Galerie PCP, Paris in November 2017. The installation transformed the gallery into a controlled plant growing environment, testing the automated rotating system's ability to grow plant food over three months. [238] Seeds were planted in a propagator tank and once germinated, seedlings were transplanted into the rock wool in the rotating wheel. *Plant Orbiter* required a power supply to run the system, including the lamps, nutrient pump and motor. This relied on the gallery wall sockets, however a renewable source of electrical power - solar or wind power - would allow the system to be sustainable. [239]

The work aimed to explore synergies with other works in the *Life-Systems series*. For example, the hydrogen electrolyser's 'waste' oxygen gas can be used to oxygenate the nutrient solution used to feed the plants thus aiding their growth and minimising bacterial growth. The postponed work *Solar Still* would provide pure water for the plant nutrient solution as well as supplying water for the electrolyser. To borrow again from Burden, my 'elaborate fantasy' would be to power the work with self-made hydrogen, using a fuel cell to transform hydrogen into electricity.

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[238] The work also utilised an audio component: Sonic Culture - Rapid Plant growth /Bloom Frequencies, Inventor DeeJay, Youtube, 20:59 mins. Rachel Carson's *Silent Spring* recounts the loss of bird populations across the US in the 1950s due to the overuse of pesticides and particularly DDT. The disappearance of bird life also had detrimental effects on agriculture with many farmers experiencing reduced harvests and crop failure. In response to this, inventor Dan Carlson developed the product Sonic Bloom which combines audio frequencies with a nutrient solution. His research claims that plants respond to certain audio frequencies, particularly those of morning birdsong, by opening the stomata on leaves and therefore becoming more receptive to nutrients which increases growth. "Sonic Bloom - Organic Nutrients for Your Plants, Garden or Farm," accessed May 4, 2021, https://originalsonicbloom.com/background.html.

[239] This has led me to initiate conversations with institutions and galleries, about switching to renewable energy tariffs.

Plant Orbiter and Usership

Gallerist Peter Cybulski financially supported the production of the work and his experience with art fabrication meant that he had a good understanding and keen interest in the production process. The exhibition required his engagement in usership with the work, a commitment somewhat beyond the everyday conventions of managing an art gallery: routine maintenance included topping up the nutrient solution, planting seedlings, harvesting plants and making minor mechanical repairs. As the primary user of the work, Peter's understanding of the role of usership in this context was critical in activating and maintaining its agency. During the exhibition, *Plant Orbiter* successfully grew crops of vegetables and herbs: lettuces, peppers, cucumbers, cabbages, carrots, basil and coriander. We discussed how he might want to use the vegetables, perhaps offering them to visitors or using them at home. Peter instead decided to let the plants overgrow the wheel. The two photos in fig. 42 show how the growth developed from the first week to the final days of the exhibition.

In the Spring of 2018, I was introduced to members of The Calthorpe Project community centre in Kings Cross at a UCL Grand Challenges networking event for public engagement partnerships. This led to a successful grant application with my PhD colleague Ellie Doney to collaborate with The Calthorpe Project. The event, titled Food Futures invited members of the public and Calthorpe staff and volunteers to a one-day workshop exploring 'food production, sustainability and closing the energy loop'. Ellie led a workshop inviting participants to make vegetarian sausages with ingredients from *Plant Orbiter* and the Calthorpe Garden which we then cooked and shared. I introduced the principles of *Plant Orbiter*, participants brought their own seeds and together we prepared the rockwool, nutrient solution and planted the wheel (fig. 45). The conversation moved between the practicalities of the work we were doing and wider issues, sharing thoughts on how food production may adapt to a changing planet.

Figure 45. Food Futures workshop with Ellie Doney at The Calthorpe Project, Kings Cross, London, March 2018, photo Adriana Arroyo

The workshop led to *Plant Obiter* being installed in the entrance hallway of The Calthorpe Project for three months of the Winter and early Spring of 2018, where it supplied 'plant orbiter salad', leafy greens and herbs for the cafe during a time when little was available from the garden (fig. 46). Staff and volunteers, many of them experienced gardeners, became interested in the machine and how it worked, growing food without soil. It also attracted

the attention of school children during after-school activities. Comments and feedback from staff and visitors indicated that *Plant Orbiter* had become a subject of interest and discussion at Calthorpe. When it came to deinstalling the work it was suggested that we might further collaborate in the future to build a rotary garden for Calthorpe's ongoing use, for further experimentation and as a teaching aid for hydroponics and urban food production.

Figure 46. Mila Campoy (left) and Annika Miller Jones at The Calthorpe Project, Kings Cross, London, March 2018, photo Nick Laessing

The following year, in 2019 *Plant Orbiter* was installed at Newlyn Art Gallery for the group exhibition *Europe After the Rain* curated by Simon Faithfull. The work was planted with leavy green vegetables that would regrow after cutting: bok choy, cabbage, varieties of lettuce, basil, parsley and edible flowers such as nasturtiums. The team of gallery invigilators looking after the work would harvest the wheel for their sandwiches.

Figure 47. *Plant Orbiter 2019* at Delfina Foundation, top: installation detail, photo Ollie Harrup, bottom: making pesto from mixed leaves for lunch with Delfina residents, photo Nick Laessing

In 2019 a second edition of *Plant Orbiter* was commissioned in partnership with Delfina Foundation and the Victoria and Albert Museum as part of my UK associate residency and for the Great Exhibition Road Festival at the V&A. Making this second work allowed me to improve certain details of the design, adding a stronger motor and replacing the chain with a belt drive to reduce the noise of the motor. During my Delfina Foundation residency for

the Politics of Food season, I presented the planting workshop, Growing Solutions with Dr Ros Gray, programme leader of the MA in Art and Ecology at Goldsmiths University (fig. 48). During the three-month period the work grew salads and herbs that were shared with artists in residence and used for visitor lunches at the house (fig. 47). I also contributed an essay on *Plant Orbiter* that reflected on the history of hydroponics and zero-gravity food cultivation for the Delfina Foundation publication *Politics of Food*.[240]

Figure 48. Growing Solutions, a *Plant Orbiter* Workshop, Delfina Foundation. 2019, Photo Ollie Harrup

[240] *Politics of Food*. Dani Burrows, Aaron Cesar, Eds. Sternberg Press Delfina Foundation, 2019.
See fig. 70, appendix.

4.4 Sun Cooker

Figure 49. *Sun Cooker*, Europe After the Rain, Newlyn Art Gallery 2019, curated by Simon Faithfull

Sun Cooker was made with the support of Sustainable UCL as part of the Sustainability Week event programme in November 2018, in the main Quad at UCL. Collaborating with PhD colleagues Ellie Doney and Nayoung Jeong, we invited students and academics for ramen noodles and a Korean tea ceremony (fig. 50). During the week we also met with our PhD cohort and Slade Lecturer in History and Theory, Larne Abse Gogarty to discuss her 2017 paper *On Usefulness in Contemporary Art and Politics*, published in Third Text.[241] *Sun Cooker* was also exhibited in the group exhibition *Europe After the Rain*, Newlyn Art Gallery 2019 (fig. 49).

Solar cookers are in common use in many parts of the world, often found in warm sunny climates, and areas lacking energy infrastructure. Various

[241] Larne Abse Gogarty, "'Usefulness' in Contemporary Art and Politics," *Third Text* 31, no. 1 (January 2, 2017): 117–132.

designs of solar cookers have been distributed as part of aid projects for refugee camps by organisations such as Solar Cookers International, which estimates over four million solar cookers are in use globally. [242] Solar cookers can be made from a range of recycled materials and can also be repurposed from discarded satellite dishes. This research also led to a solar cooker workshop as part of the Ecologies of Art and Making Foundation Taster course in Hackney Wick, 2020.

Parabolic solar concentrators are a common design and effective at reaching high temperatures in direct sunlight. *Sun Cooker* is made from 16 panels of 3mm plywood sheet, PVA adhesive, mild steel and reflective aluminium tape. When correctly aligned it boiled a pot of water in about fifteen minutes in the November sun. The shiny metallic dish was quite an attraction, people passing would often stop for a few minutes, ask questions and enjoy a cup of tea with us. Making and experimenting with this work, I discovered how effectively it demonstrates a simple, cheap and practical clean energy technology. On one occasion, after returning to my studio and boiling an electric kettle, I was suddenly confronted in a very direct way by how this felt different. This experience exactly relates to the term I developed during my research, a *feeling of function*, to describe how these kinds of interventions are *differently felt* as they align with utopian experience and the notion of the utop.

[242] "Distribution of Solar Cookers :: Solar Cookers International," accessed May 4, 2021, https://www.solarcookers.org/partners/distribution-solar-cookers.

Figure 50. Collaboration for UCL's Sustainability week, November 2018, photo Nick Laessing

Making this work also gave me the opportunity to test the effectiveness of a parabolic dish to purify tap water (or also other water sources such as rainwater or sea water) for electrolysis. In such a system, the sun's heat causes only the water to evaporate, leaving behind any impurities, as it cools the condensation is captured as purified water. Such a device would also find other uses within the *Earth Systems* ecology of technologies, such as cooking, drinking and supplying the *Plant Orbiter* nutrient solution avoiding scale from and other impurities of tap water. The completion of the solar still was postponed due to the Covid-19 lockdown.

4.6 Interdisciplinary Practices

> *Like industrial production, research and development take place in a highly compartmented manner. The artist, primarily, and with the maximum possible freedom following his own interests and work, can serve as a unique bridge between department and department in industry, and within a university, from one research laboratory to another. He can act as a bearer of ideas, information, intuitions, and techniques and· materials; his presence can serve as a stimulant and irritant, his questions and ideas will tend to disorient, undermine and re-route established, ritualized, ways of thinking and doing.* [243]

The term 'interdisciplinarity' has, almost prosaically, become a byword of the Anthropocene. And yet it is undeniable that the Anthropocene has forced collisions of hitherto disconnected areas of knowledge, and epistemological disruptions and adaptations that embrace new models of complexity. These new cultural paradigms meet with mental stress, discomfort and resistance; we are learning, as Haraway says, to 'stay with the trouble'. Artistic practices - acts of transgression, reflection, and speculation, across disciplines, as public dialogue –have demonstrably embraced these epistemic challenges. Bookchin's call for a '[scientific] discipline that allows for indiscipline', [244] finds essential efficacy in the rationale of the Anthropocene. The purposeful practice of *indiscipline*, as evident in many examples of artistic practice [245]

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[243] Automata in History, Metzger, G. Automata in history. Studio International. March 1969, p107-109. Gustav Metzger - Monoskop [Internet]. Monoskop.org. 2018 [cited 9 February 2018]. Available from: https://monoskop.org/Gustav Metzger

[244] He continues 'imagination and artfulness... that integrates critique with reconstruction, theory with practice'. See full quote in section 3.3.

[245] See Atkinson: 'The nature and force of art practice is what I call disobedient: disobedient to established parameters of practice, practices of thinking, seeing, making and feeling.'

also finds efficacy in navigating the epistemological challenges of the Anthropocene. These shared modalities of indiscipline have perhaps contributed to the coalescence of artistic and Anthropocene dialogue.

> *Pluralism of theories and metaphysical views is not only important for methodology, it is also an essential part of a humanitarian outlook.* [246]

The site-specific, long term art project *Seeds of Change* by Maria Theresa Alves successfully demonstrates this kind of artistic *indisciplinary* knowledge-making. Intensive periods of archival research, fieldwork and scientific collaboration led Alves to important historical discoveries about the slave trade and the use of ballast in slave ships (which Alves claims were initially refuted by historians). In *Seeds of Change*, this knowledge is not by-product, but intrinsic to and embodied in the work. [247]

The fields of geography, geology, decolonialism and aesthetics align in Yusoff's A *Billion Black Anthropocenes or None,* to form the basis for her thesis of the Anthropocene as a colonial event. This approach has impacted the current understanding of the geological chronology of the Anthropocene and connects ongoing racial injustice with ecological crisis. In this discussion Yusoff includes examples of artists work such as *Caribs' Leap/Western Deep* (2002) by Steve McQueen as she discusses a 'Black Aesthetics for the end of the World'. [248] Similarly, Haraway, having trained in biology and zoology, went on to address feminism, technology, art and ecological theory, becoming a key contributor in interpretations of the Anthropocene. Another example is

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[246] Paul Feyerabend, *Against Method*, 3rd ed. (London ; New York: Verso, 1993).

[247] See "Maria Thereza Alves - Seeds of Change," accessed May 4, 2021, http://www.mariatherezaalves.org/works/seeds-of-change?c=.

[248] Kathryn Yusoff, A billion black Anthropocenes or none, 2018, 89.

found in Chakrabarty's work that bridges colonial history with geology to develop new interpretations of humans as agents of geological time. [249]

Collaboration and interdisciplinarity are often symbiotic, interdependent processes – collaboration often involves working across disciplines, and interdisciplinary work often requires collaboration. Zylinska's ethical collaborative thesis for the Anthropocene is demonstrated in these kinds of interdisciplinary Anthropocene practices of Alves, Yusoff, Haraway and Chakrabarty.

What are the conditions required for collaboration? In my partnership with the EIL, I was initially challenged by my unfamiliarity with researchers, staff and their work. In my first weeks of the PhD, I formally presented my artwork to the EIL research group. It was difficult to gauge a response. This feeling was also likely due to my own distinct sense of imposterism in presenting my autodidactic knowledge of water electrolysis to a group of PhD scientists and their professors for the first time. Initial tensions were overcome through the good will and support of my EIL supervisor, Professor Dan Brett and collaborating with UCell, the EIL public outreach group, on public outreach activities - presenting EIL research at science museum activities, and university open days, and joining social events outside the laboratory. The voluntary nature of these activities equalised our relationships; friendships were formed during travel to events, setting up the presentations, collaborating in discussions with members of the public and evenings spent socialising. Meetings in the lab and asking for advice felt easier after getting to know researchers informally and discovering shared interests. Forming these relationships also led to two successful UCL grant applications for public outreach projects.

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[249] For more examples of expanded interdisciplinary practices, see HKW's Anthropocene Curriculum
https://www.anthropocene-curriculum.org

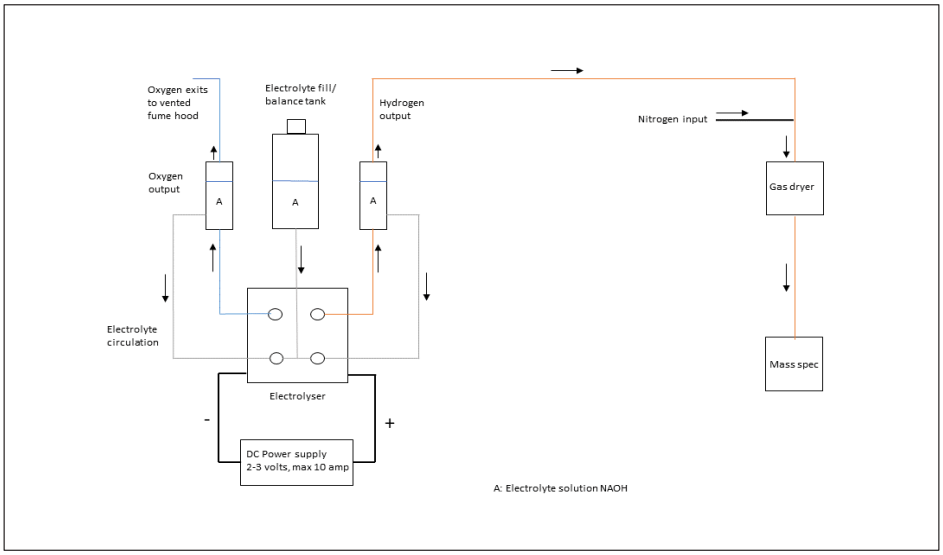

Figure 51. Risk assessment diagram for gas purity test with mass spectrometer at EIL, 2018, Nick Laessing

Designing, fabricating and testing my hydrogen system proved at times challenging given the health and safety requirements of both my studio at the Slade and the EIL. This context was significantly different from the remote workshop in Devon where it was possible to make a test by taking the device outside into an empty field and keeping a safe distance away from any potential hazard. Working with a flammable gas in a laboratory shared with other researchers, it was necessary to meet the strict levels of health and safety at the EIL. I enrolled in the lab's health and safety courses and completed a gas connection course with Simon Barass, the department of chemistry's safety officer. This contributed to establishing trust and good working relationships in the laboratory. With help from EIL researchers I became familiar with the protocols of lab practice, learning to write a risk assessment for my experiments (fig. 51). This was very time consuming, but the experiences proved invaluable, the gas analysis was a key part of my research and led to the successful completion of the electrolyser. This work depended on the support and good will of EIL researchers who took time out of their day to help me.

This project has led me to reflect on theoretical interpretations of scientific research and its relation and tensions with aesthetics. Reading Isabelle Stengers [250] introduced me to the work of mathematician and philosopher Alfred North Whitehead. In *Process and Reality* (1929) [251] he argues that scientific objectivity has achieved authority as the 'primary reality' (its abstractions guiding cultural narrative), over the 'secondary reality' of subjectivity or aesthetic experience.

> *Whitehead called the radical divorce of humans (and cognition) from our scientific conceptions of nature, dating back to Descartes and Newton, "bifurcation"...[whereas for Whitehead] feeling, aim, mind, value, in their abstract sense were just as much as part of modern physical reality as quantized energy , and four-dimensional space time.* [252]

For Whitehead, the abstractions of science should not hold authority over or guide cultural experience. He describes this problem as 'the fallacy of misplaced concreteness' and argues for a reinstatement of philosophical thinking as a creative and moral tool for building human cultural narrative (and by implication guiding scientific research). [253] According to Whitehead, metaphysical discovery can be likened to the take-off, flight and landing of

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[250] Isabelle Stengers, *Thinking with Whitehead: A Free and Wild Creation of Concepts* (Cambridge, Mass: Harvard University Press, 2011).

[251] Alfred North Whitehead, *Process and Reality* (Free Press, 2014) accessed April 14, 2021, http://www.myilibrary.com?id=893479.

[252] "The Influence of A.N. Whitehead on the Future of Ecological Economics," *Center for Humans & Nature*, accessed April 14, 2021, https://www.humansandnature.org/the-influence-of-a.n.-whitehead-on-the-future-of-ecological-economics.

[253] This idea of infusing science and technology with subjectivity, 'feeling, aim, mind, value' connects with my methodology of the *feeling of function* that aims for an ethics of technology as experienced through usership.

an aeroplane 'from concrete experience to abstract systems and then back to concrete applications'.[254] This ongoing movement and play between imaginary (utopian) abstractions and usefulness or utility - flights of speculation for earthbound problem solving - is a striking model for a praxis that attempts to combine aesthetic approaches with scientific discipline in response to ecological emergency.[255]

> *How are we to use the sciences and who decides the matter?*
> *...a community will use science and scientists in a way that agrees with its values and aims, and it will correct the scientific institutions in its midst to bring them closer to these aims.*[256]

In *Against Method: Outline of an Anarchistic Theory of Knowledge* (1975), Paul Feyerabend, though not directly referencing them, concurs with Whitehead and Bookchin, in claiming that the values and aims of a community must precede and instruct the applications and trajectory of science. He also similarly recognises the need for a renewed grasping of art's role and value in society, and invokes its transformative agency,

> *It is possible to retain what one might call the freedom of artistic creation and to use it to the full, not just as a road of escape but as a necessary means for and perhaps even changing the features of the world we live in.*[257]

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[254] Michel Weber, ed., *Handbook of Whiteheadian Process Thought*, Process thought / ed. by Nicholas Rescher Vol. 1 (Frankfurt: ontos, 2008), 42.

[255] We might contemporize this metaphor into a space-flight metaphysics for an expanded, deep space imaginary, in response to the greater earthbound urgencies of the Anthropocene.

[256] Paul Feyerabend, *Against Method*, 3rd ed. (London ; New York: Verso, 1993). p 251

[257] Paul Feyerabend, *Against Method*, 38.

Feyerabend argues that community must act as a corrective overseer of the scientific institution and in doing so he adds a democratic component to Whitehead's aeroplane-metaphysics. As a Professor of Philosophy at the University of California in Berkeley, he was distinctly aware of the epistemic limitations of his teaching. He describes this task as carrying out 'the educational policies of the State of California... to teach people what a small group of white intellectuals had decided.' [258] His *referent-we community* is the ecumenical, universal referent-we of Wynter 'that has replaced liberal monohumanist Man2'.

Gustav Metzger's art practice and his 1969 essay *Automata in History* has been an important reference for this project. Metzger was born in 1926 into a Jewish-Polish family in Nürnberg. He was evacuated from Nazi Germany to England with his brother in the Kindertransport and his parents were killed during the war. [259] Sensitive to the destructive traits of humankind, Metzger developed what he described as an 'aesthetics of revulsion' for his 'Auto-Destructive' art installations and performances. His essay *Automata in History* is a manifesto of sorts that warns against the unchecked development of technology or what Bookchin referred to as the problematic 'model of the technological imagination' and argues that the role of the artist is critical as a force of ethical input and agency in the field of scientific research. In my association with the department of Chemical Engineering at UCL I found myself reflecting on Metzger's statement quoted at the beginning of this section. There was undoubtedly a sense that my presence as an artist provoked

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[258] He describes this epistemic crisis: 'These were the thoughts that went through my head as I looked at my audience and they made me recoil in revulsion and terror from the task I was supposed to perform. For the task- this now became clear to me - was that of a very refined, very sophisticated slavedriver. And a slavedriver I did not want to be.'

[259] "Forum for Holocaust Studies: Introduction to the Historic Photographs of Gustav Metzger," accessed April 14, 2021, https://www.ucl.ac.uk/forum-for-holocaust-studies/metzger.html.

different kinds of conversations with colleagues that crossed into the wider roles and potentials of technology and research. Building a complete electrolysis system to produce hydrogen was an unconventional project in this context of compartmentalised research and yet I was able to locate the advice and support necessary for its completion. This also led researchers to follow the outcomes of the work; a sharing of ideas and research evolved into collaborative projects such as a one-day workshop at The Calthorpe Project and a collaboration with the UCL department of civil engineering on a microbial fuel cell installation.

Metzger's awareness in the 1960s of the potentials for artistic input as an ethical, critical and creative influence on the direction of scientific and technological research bears out Whitehead's and Feyerabend's arguments, in calling for renewed importance to subjectivity and creative input in shaping the narratives that we choose to live by, which in turn shape the trajectories of scientific progress.

Whilst recognising the transformative potentials of art and creativity - that its emancipation from Whitehead's secondary reality potentialises the creation of new narratives, affecting the world we live in - it is important to perceive how this can be executed *on the ground*, as a community embedded praxis, and without deferring to conventions of valorising the role of the artist. Metzger's words at the start of this section emphasise the importance of the artist as 'serving as a unique bridge...a bearer of ideas' across departments, he states that the artist may act as a 'disrupter and irritant' in such a relationship. Where Metzger's practice tends towards individualism and antagonism (disrupter and irritant), this project has aimed to engage with planetary ecological problems by exploring the notion of community as instances of solidarity and mutuality and to use this as a basis for *indisciplinary* collaboration across academic and non-academic contexts.

I am currently working with researchers across the Institute of Education, the Department of Civil, Environmental & Geomatic Engineering, and the Electrochemical Innovation Laboratory UCL, following a successful collaborative application for the UCL Grand Challenges Transformative Technology Award. [260] At the award's collaborative networking event, I met PhD researcher Enrique Lopez Arroyo and his supervisor Dr Luiza Campos from the Department of Civil, Environmental & Geomatic Engineering, and Dr Eileen Kennedy, UCL Institute of Education (IOE) Knowledge Lab, whose research focuses on Massive Open Online Courses (MOOC). Together we developed a proposal to scale up Enrique's laboratory experiments with microbial fuel cells – small jars filled with microbial material (for example soil or mud), that generate sufficient electricity to power LEDS. Enrique is keen to test the potentials of the waste digestate from Calthorpe's biodigestor to 'fuel' his microbial fuel cells (MFCs). The aim of the project, titled *Scaling Waste to Energy Technology: From Local to Global Community Engagement* is to create a larger bioelectric energy system 'sculpture' that converts organic waste to electricity, for The Calthorpe Project garden, to illuminate the garden and charge mobile phones. We will integrate this and other community engagement events into a sustainable energy 'MOOC', with activities and resources on community-based engineering solutions that will be available in Arabic and English for collaboration with IOE partners in Beirut.

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[260] The Grand Challenges Transformative Technology programme, special initiative
'Engineering Solutions to the SDGs' Scaling Waste to Energy Technology: from local to global community engagement, with:
-Dr Luiza Campos - Department of Civil, Environmental & Geomatic Engineering
-Jen Hack - Electrochemical Innovation Lab (Engineering Sciences)
-Andreea Ionascu – Slade School of Fine Art MA Alumna
-Dr Eileen Kennedy - UCL Knowledge Lab (Institute of Education)
-Enrique Lopez Arroyo - Department of Civil, Environmental & Geomatic Engineering
-Aneeba Rashid HEC PhD Scholar Government College University, Lahore

The project has made steady progress despite the delays over recent months due to Covid-19. We learnt to run tests and experiments over Skype and Teams. Slade School of Art MA Alumna, Andreea Ionascu worked from home on the fabrication of the project, which is now installed at Calthorpe and being prepared for workshops which will be delivered remotely. My artistic input in the project was effective in preparing and articulating the funding application and in the codesign and fabrication of the bioelectric installation. This involved working remotely with Andreea, who fabricated the work and Enrique who advised us on the technical requirements for the MFCs. Public engagement activities will involve making small-scale MFCs with participants, while also engaging with the wider issues I address in my research regarding the roles of technology and interdisciplinary collaborative work in response to ecological crisis. Documentation of these activities will then be integrated into Eileen's research and find further dissemination as a MOOC.

This collaboration across science, art and education, still in progress, presents an interesting case study for interdisciplinary work. Over the past months, as we have developed the project through group conversations, our practices and methodologies have interconnected to the extent that we now feel able to advise each other in our various areas of knowledge. Our project has evolved to become a shared platform of reciprocal learning based on a collective curiosity and enthusiasm to realise this shared goal – to develop a simple yet affective renewable energy technology that can be disseminated across different platforms, from a community centre in Kings Cross to an online learning platform with potential for global outreach.

4.7 Social Practice, Teaching and Utops

> *Art practice as an ethico-aesthetic and political process... has generative potential for producing new modes of becoming and new forms of coexistence. In other words, the force of art can take us beyond the human as is constituted into new modes of becoming.* [261]

Social practice

As an art practice in dialogue with Bruguera's criteria of Useful Art, that aims to replace 'authors with initiators and spectators with users', [262] this project connects with the intersections of social practice and pedagogy. Sites of usership and social practice included a car repair workshop in Devon, my PhD studio, The Calthorpe Project, Galerie PCP, Bergamo Museum of Modern Art, The Delfina Foundation, and Newlyn Art Gallery.

Meeting Rokiah Yaman at a UCL public engagement networking event in 2017 was an important step for my research, and led to several workshops and events at The Calthorpe Project (including Hydrogen - Fuel of the Future? Useful Art A Working Group, and Food Futures). Rokiah is a community educator and coordinator of the living lab initiative at The Calthorpe Project. As director of LEAP Micro AD she has devised and led several biogas generator installations across London, including at Calthorpe. Established in 1984 as a non-profit community centre, The Calthorpe Project on Gray's Inn Road, Kings Cross, is a multifaceted community resource serving numerous functions: cafe, garden, kindergarten, allotments, five-aside-football pitch and food bank. It has established long lasting relationships with a diverse demographic of visitors and volunteers and is just a few minutes' walk from

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[261] Dennis Atkinson, *Art, Disobedience, and Ethics: The Adventure of Pedagogy* (Cham: Palgrave Macmillan, 2018), 1.

[262] See arte util criteria, section 3.3.

the UCL main campus. Calthorpe's focus on sustainability incorporates a living lab and circular economy philosophy: growing food for the cafe, recycling facilities, food waste composting and renewable energy pilot projects. Calthorpe's ethos and its established relationship with UCL in public engagement, led to productive collaborations and ongoing projects.

I taught the five-seminar course *Navigating the Anthropocene* with Slade BA first year students for three years, which introduced artist practices and discourses of the Anthropocene through aspects of my research. Engaging with students on this subject has been extremely rewarding –they were very responsive during seminars and made impressive contributions when asked to share their research in group discussions. Some students from these courses volunteered to help me in my studio work and have also assisted with workshops and exhibitions.

In 2019 I facilitated a four-day *Life-Systems* climate crisis workshop and exhibition with year eleven and twelve students at Bergamo Museum of Modern Art, Italy. This explored the concept of energy-ecologies and Useful Art, re-imagining our relationship with technology and energy systems. We looked at artist practices that connect environmentalism, climate breakdown and technology. Students were encouraged to imagine their own responses to these themes. Over the week, they created their own collaborative art installation using a stationary bicycle and repurposed electric drills to generate human powered electricity. The resulting installation presented a charging station for visitors' phones, a bicycle powered video installation, sketchbook presentations, large-scale drawings of mind maps and Fridays for Future protest artwork.

In 2020 I codesigned and facilitated the five-day course *Ecologies of Art and Making* with PhD colleague Ellie Doney, a pilot/taster foundation short course for the Slade School of Fine Art in Hackney Wick, East London. The course aimed to introduce students to an expanded understanding of

ecologies, introducing concepts of agency in the context of local and planetary scales of connectedness. Through engagement with making across the disciplines of art, technology and the built environment, we explored the connectedness of materials, practices, individuals and communities, working from the studio and making exploratory walks in the local area. Students were encouraged to experimentally explore notions of ecologies through their own experiences and stories, leading to the development of a portfolio, and the hosting of a group exhibition. Students were fully engaged with the course and made impressive contributions. On the final day, for their exhibition, they decided as a group to exhibit their work outside in the local woodland, Wick Wood.

Both teaching and the social practice of Useful Art have helped me to articulate and share my research across different contexts that also brought together academic and non-academic communities within this practice.[263] These activities aimed to generate contexts of community for dialogue and

[263] Ross H Schlemmer introduces the term Socially Engaged Art Education in his 2017 paper, Socially Engaged Art Education: Defining and Defending the Practice. He states, 'SEAE recognizes the community's ability to provide both context and content for learning. This framework is uniquely suited for this encounter, not from a position of power or authority, but rather by creating multiple perspectives and reference points from which to make meaning of our experiences. It presents the opportunity to develop socially relevant programs for use in the teaching of art that include community, social justice, democracy, collective responsibility, activism, and equity—amongst others—that confront established perceptions of both art and education.'
Leigh Nanney Hersey and Bryna Bobick, eds., *Handbook of Research on the Facilitation of Civic Engagement through Community Art*, Advances in Media, Entertainment, and the Arts (AMEA) book series (Hershey: Information Science Reference, 2017).

reciprocal learning [264] that can approach the challenging existential issues of our 'habits-of-being' and look towards 'horizons of hope'. [265]

Exploring the Anthropocene through interpretations of utopia became an effective framework to approach teaching and facilitating workshops. Reading Le Guin's 'A Non-Euclidean View of California as a Cold Place to Be' as a group was a particularly effective way into to these discussions. The text's wide-ranging reflections on interpretations of utopia evoke a complex dialectics of unease and hopefulness through fictioning and storytelling. Discussions on the notion of the utop were also effective in reflecting on agency and scalable approaches to ecological problems.

The Utop

A main goal of this research has been to find ways to address the Anthropocene experience through a utility-centred, co-learning practice that engages with utopian narratives. Identifying with the agency of the utop has led me to reflect on my own encounters with this 'partial step towards a utopia, a concrete actionable realisable goal that moves us forward in the direction of where we imagine utopia to be':

- Working with Jimmy Whitmore and Jonah Kinross in Devon on *Water Gas Car*, we were about to make our first test after rebuilding the electrolyser. We inflated a large black refuse sack with our home-made gas and connected it with a long hose to the Golf's

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[264] De Sousa Santos describes this as a practice of 'non-extractive reciprocal pedagogy'. Santos, Boaventura De Sousa, and Queni N. S. L. Oeste. *The End of the Cognitive Empire: The Coming of Age of Epistemologies of the South / Boaventura De Sousa Santos.* 2018.

[265] I borrow these phrases from Sharon Stein, "The Ethical and Ecological Limits of Sustainability: A Decolonial Approach to Climate Change in Higher Education," *Australian Journal of Environmental Education* 35, no. 3 (November 2019): 198–212.

engine intake. Jimmy turned the ignition key, the starter motor turned over and suddenly the engine roared into life, its vacuum quickly deflated the gas bag, leaving a puddle of water under the exhaust pipe. The barn echoed with celebratory whoops and lots of swearing out of sheer amazement.

- Sitting around a weathered table in a quiet corner of the Calthorpe Project garden, I introduced members of UCell to Rokiah Yaman in the warm sunshine. Forgetting ourselves and getting slightly sun burnt, we dreamt up a hydrogen injection experiment for Calthorpe's biodigester to help it to run at far greater efficiency.
- At the Hydrogen - Fuel of the Future? event at Calthorpe, I assembled an electrolyser with Diego, (an environmental engineer working on biogas at Calthorpe), explaining how it worked. Suddenly I sensed his excitement as he gasped and started quickly speaking about its potentials.
- At the Food Futures workshop I approached Tom, a football coach at Calthorpe, noticing he had been quietly staring at *Plant Orbiter* for some time. We had a lengthy conversation about food, his family and their politics, vegetarianism and voting Labour, as we both, slightly hypnotised, stared into the illuminated rotating wheel.
- Also at the Food Futures workshop, Iona's five-year-old son Toma was extremely dissatisfied that *Plant Orbiter* was plugged into the wall socket, he busied himself with paper and crayons, sketching out a much improved solar-powered *Plant Orbiter.*
- Having met chemical engineer and academic Charlie Dunnill at the Petrocultures conference in Glasgow, I visited him at his home in Swansea where he showed me his home-made hydrogen electrolyser and BBQ installed next to a chicken coop in his back garden. This was my first direct encounter with another hydrogen DIY project. I was fascinated to see the utopian spirit that infused Charlie's academic research.

- Working in the EIL lab I met PhD researcher Josh Bailey, a founding member of People Power, a loose knit group of scientists and engineers raising awareness about clean energy technology and sustainability through educational programmes. Josh and I worked closely on the Hydrogen Fuel of the Future? event and more recently he offered helpful advice on the first stage of what became a successful 'Engineering Solutions to the SDGs' UCL grant application for a collaborative project with UCL Dept of Civil, Environmental & Geomatic Engineering and UCL Institute of Education (IOE).
- This project, titled 'Scaling waste to energy technology: from local to global community engagement' involves scaling up a microbial fuel cell to produce useful electrical power. Based on the research of Enrique Lopez Arroyo (Department of Civil, Environmental & Geomatic Engineering), it is also being developed into a sustainable energy MOOC with Dr Eileen Kennedy (IOE), for collaboration with IOE partners in Beirut. [266] In a recent WhatsApp message, I mentioned to Eileen that I was preparing a presentation of our collaboration. She replied, 'I love this project' and when I asked why, she replied:

> *There are a few things. One is ambition - to provide a beautiful solution to the challenges re: water-energy-food; the second thing is the commitment of everybody even under lockdown; the third is that the result is beautiful, [it] immediately makes you change your perspective about what is possible –*

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[266] For more info see: UCL, "Current Activities," *UCL Grand Challenges*, last modified February 14, 2020, accessed April 20, 2021, https://www.ucl.ac.uk/grand-challenges/ucls-six-grand-challenges/transformative-technology/current-activities.
Work in progress photo blog: https://www.flickr.com/photos/189009240@N02/albums/72157714910120601

and is scalable; and the third is that it is a great way of engaging the community – showing people what can be done and starting a meaningful conversation... I feel honoured to be involved tbh [sic].

- Soon after my workshop at the Bergamo Museum of Modern Art, I received an email from the father of a student, to say that his son David was now considering a career in environmental work:

> *David told me you shared with them beautiful moments, you tried to learn some Italian card games and enjoyed our local ice-cream. Most of all, the experience was so amazing that my son started to think that the environmental engineering discipline could be a good place to spend his life. [I]Don't know how [the] future will be, but I really wanted to tell you that you put a seed into his mind.*

4.8 Conclusions and Summary: Towards an Anthropocene Ontology

An Anthropocene Praxis

My primary research question asks: what are the requirements for an art practice of the Anthropocene that confronts ecocrisis? The course of this investigation has led me to work towards an ethics of practice for the Anthropocene, that seeks efficacy. As a praxis that applies technology to the criteria of Useful Art in response to ecocrisis, the project reaches out beyond the institution and the studio into the everyday, towards an ontology of everyday experience. In this sense this praxis has come to address associated existential responses such as guilt, hopelessness, anxiety, and limits to futurity, that may suppress, inhibit, or deny creative counter responses.

The praxis or aesthetic proposal that I have developed firstly identifies with the reflexivity of Wynter's 'referent-we'. It asks who 'we' are, recognising and understanding alterity created by the liberal monohumanist 'we' and replacing this with a universal 'referent we' that exists as 'whole human community'. [267] Secondly it follows Zylinska's ethical thesis of precarity and vulnerability, finding collaborations and contaminations in this new referent-we community (discussed at the end of section 3.3). Thirdly it imagines the decolonisation of the utopian narrative: creative, yin anti-anti-utopian collaborative responses and makes them actionable – achieving response-ability – in the 'utop' or micro-utopian event. I propose this not as a linear exercise or a set of rules to follow, but as a nonlinear aid to thinking and acting that engages with the intersections of social practice, activism, Useful Art and

[267] Here I paraphrase Wynter and her use of Latour's 'whole human community'. McKittrick, Katherine. Sylvia Wynter: on Being Human as Praxis. Durham: Duke University Press, 2015, 18.

pedagogy, and that aims for *liveable collaborations for collaborative Anthropocene survival.*

Art and Technology

Bookchin's emphasis on pre-thinking ethical and political frameworks for the applications of technology, (also supported by the work of Whitehead and Feyerabend), rather than allowing it to find its own political structures in partnership with capitalism, has been influential for this investigation. It has led me to focus on the importance of ethics in a praxis that engages with technology and to embed interdisciplinary work in aesthetic thinking. To only address the technological and scientific challenges of producing low-cost renewable hydrogen for this project would sidestep the wider political and social questions regarding the role of technology and its relationship with ecological crisis. It would ignore the historical relationships of colonialism, technology and the Anthropocene, and also reflection on my own position of white-European-academic privilege within those relationships. The historical similitudes of the white male inventor/industrialist, in part justifiably valorised as creative and transformative, is at the same time complicit in establishing multiple alterities, and in relation to industrialisation, complicit in the yang utopia of ecological devastation through engagement in toxic industrialised processes, resource extraction and CO2 emissions. Embedding this project in an artistic framework enabled a position of criticality in questioning such tropes. Holding this criticality proved helpful in for example addressing the intersections of finance, technology, and cultural production, and in identifying my own position within this research context. This also emphasised the importance of scale, agency and specificity in my research.

The Agency of Hydrogen

At the outset of this investigation, the attempt to collaboratively build a low-cost solar-powered hydrogen electrolyser and use hydrogen gas to power a VW Golf car by repurposing its factory petrol engine, proved a successful first stage of the project. Unable to initially monitor gas mixtures, we did not

store large quantities of gas due to health and safety concerns. As an installation, this work was exhibited at FACT, Liverpool. Building on this experience, and with the support of the Electrochemical Innovation Laboratory at UCL I redesigned the electrolyser to achieve hydrogen gas levels above 99% in purity which made it possible to safely use and store hydrogen gas. This was achieved through my research and experimentation with gasket design, and using Zirfon, an industry standard gas membrane to separate oxygen and hydrogen as the gases were generated.

The use of the mass spectrometer at the EIL with help from researchers, allowed me to make precise gas concentration measurements as I tested different gasket designs and gas separation membrane materials. The mass spectrometer enabled me to calibrate a low-cost oxygen analyser, for testing gas purity outside the lab. This contributed towards the evolution of a safety protocol for an unconventional hydrogen practice that coupled scientific knowledge with posteriori, experienced knowledge of practice. The resulting hydrogen electrolyser was developed into the art installation *Hydrogen Kitchen* and was exhibited in 2019 at the Institute of Making public open day GASES, the group exhibition *Experimental Futures* Rostock Kunsthalle, Germany and was used for events at Delfina Foundation in London during the *Science Technology Society* 2019 season.

Water Gas Car and *Hydrogen Kitchen* addressed the agency of hydrogen in an art practice of the Anthropocene and its potentials for utility in an aesthetics of usership. These works accessed and democratised the promise of this long-predicted energy paradise within an art practice. Creating this non-polluting gas sustainably and using it in acts of collaboration aligns with the liveable collaborations of Joanna Zylinska and the yin anti-anti-utopian encounters of Ursula K Le Guin. Engagement in acts of usership invites the spectator or viewer into this ethical response or *feeling of function,* whether driving the *Water Gas Car*, cooking with the *Hydrogen Kitchen* or eating the food it cooks. The works *Plant Orbiter* and *Sun Cooker* exist as elements

within this ecology of mutually supporting technologies and similarly seek alignment with anti-anti-utopian yin forces and liveable collaborations. These works aim towards re-experiencing our relationship with technology as ethical, aesthetic and ecological experience that is grounded in communitas, or as Bookchin would say, the social matrix.

Such artistic utopian temporalities, instantiated in the *everyday real world* through a practice of Useful Art, transform the agency of art - no longer a model, it is 1:1 scale.[268] Though perhaps speculative in its temporality, its agency contaminates and collaborates with everyday experience. This is a practice that potentialises radical transformative agency for the Anthropocene.

[268] See section 3.3 on Bruguera's Useful Art criteria.

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7. Visual Documentation: USB Stick

8. Appendix

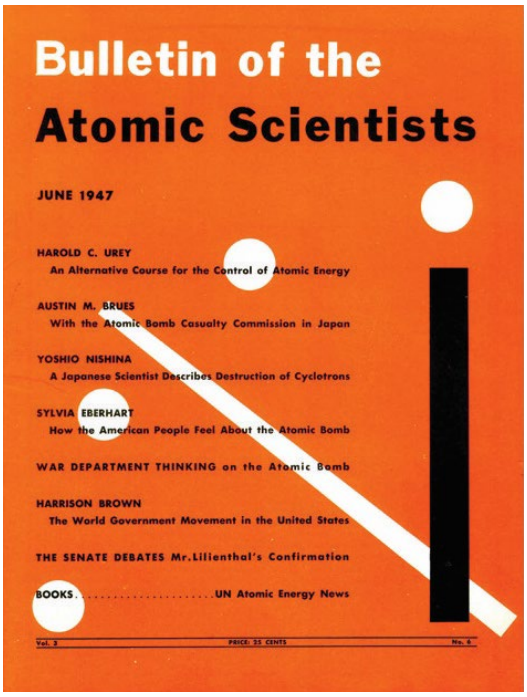

Figure 52. The Doomesday Clock 1947, "No Surprise: Scientists Have Moved the Doomsday Clock Closer to Midnight | History News Network," accessed April 23, 2021, https://historynewsnetwork.org/article/168095.

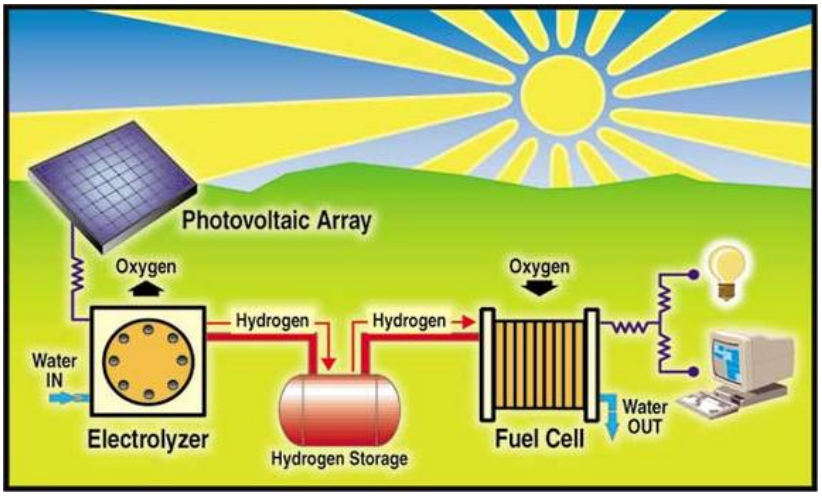

Figure 53. The Solar Hydrogen Cycle
"Hydrogen House Project: Why Hydrogen?," *Hydrogen House Project*, accessed April 23, 2021, https://hydrogenhouseproject.org/whyhydrogen.html.

Figure 54. Mike Stritzki's Hydra solar hydrogen mobile generator and water purifier
"Hydrogen House Project: Hydra Water Purifier," *Hydrogen House Project*, accessed April 23, 2021, https://hydrogenhouseproject.org/hydra-mobile-generator--water-purifier.html.

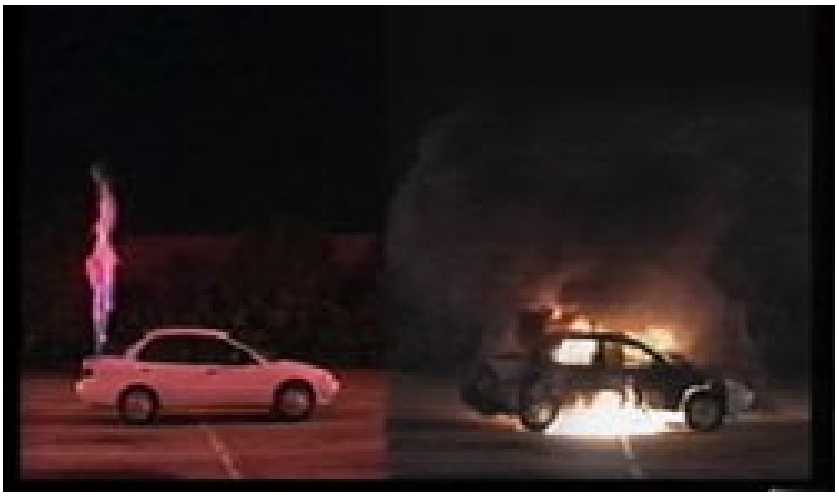

Figure 55. "Hydrogen Is Safe," *Zett Zero*, n.d., accessed April 23, 2021, https://zettzero.com/en/hydrogen-and-technology/hydrogen-is-safe/.

Figure 56. Karl Kordesch's 1970 Hydrogen Fuel Cell Car. Used for over three years as daily transportation. . Karl Kordesch, Industrial and Engineering Chemistry 52:4 (1960), pp. 296-298; Kordesch K.: Fuel Cells and their application, Weinheim VCH 1996

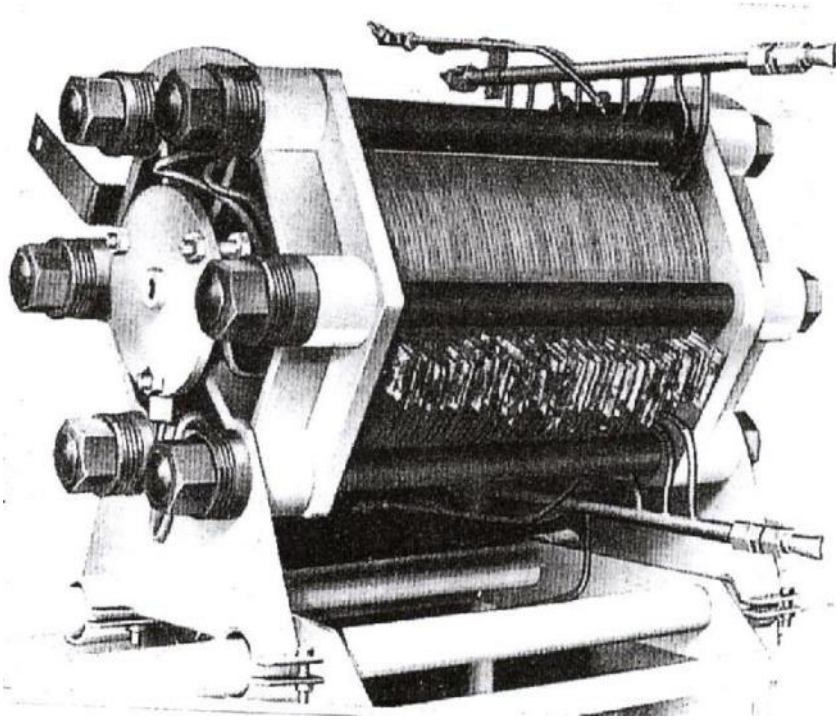

Figure 57. Francis Thomas Bacon's stack of hydrogen-oxygen fuel cells, demonstrated in 1960, it was the first alkaline fuel cell Fuel Cells, Vladimir S. Bagotsky [Internet]. Knowledge.electrochem.org. 2018 [cited 13 February 2018]. Available from: http://knowledge.electrochem.org/encycl/fig/f03/f03-f05b.jpg

Figure 58. Ford Motor Car with gas bag, Liverpool 1917, US gas bag car 2nd World War; in China, gas bag busses ran until the 1990s
"Old Liverpool Generated by VisualSlideshow.Com," accessed April 23, 2021, http://spang.org/OldLiverpool/.
"The Truth About Cars - The Truth About Cars Is Dedicated to Providing Candid, Unbiased Automobile Reviews and the Latest in Auto Industry News.," *The Truth About Cars*, accessed April 23, 2021, https://www.thetruthaboutcars.com/.

Figure 59. *Water Gas Car*, video still, 2016, Camera Elisabeth Laessing

Figure 60. Gustav Metzger, *Mobbile,* 2015, Mexico, Fundación Jumex Arte Contemporáneo, picture Colin Swan

Figure 61. NASA, *English: Astronaut Carl E. Walz, Expedition Four Flight Engineer, Works on the Elektron Oxygen Generator in the Zvezda Service Module on the International Space Station (ISS).*, April 26, 2002, http://spaceflight.nasa.gov/gallery/images/station/crew-4/html/iss004e11792.html, accessed April 23, 2021, https://commons.wikimedia.org/wiki/File:ISS-04_Carl_E._Walz_works_on_the_Elektron_Oxygen_Generator_in_the_Zvezda_Service_Module.jpg.

Spec for alkaline electrolyser
6400 litres per day hydrogen output or 4.4 litres per minute.

An alkaline water electrolyser to provide approximately 1 hour of cooking gas per day.
The electrolyser is designed around daily cooking needs of 1-3 individuals. It will be powered by a 1200 watt solar panel system. On sunny days the electrolyser should produce approximately 4 litres of H2 per minute. Given 6 hours of sunlight this should produce 1440L of gas per day. Gas will be stored in a 1500 litre butyl rubber gas bladder and will be used as required.

A self-built hydrogen gas stove made of mild steel pipe with approximately 20 x 0.5 mm bores will require approximately 20 litres per minutes of hydrogen gas at a pressure of 0.5 bar. (A single microflame requires 1LPM).

120 volt electrolyser stack
Electrolyte solution: sodium hydroxide
Inside gasket diameter 14 cm
Plate active area 153 cm2
61 stainless steel electrode plates, 60 cells
2 volts per cell at 11 amps, 1320 watts
Maximum amps per stack: 12.88
Oxygen output 2.296 litres per minute
Hydrogen output 4.595 litres per minute
Size of stack: approximately 25 x 25 x 40 cm

Budget:

1) Electrodes
61 x 316L stainless steel plates, 20cm x 20cm, 3.24 per unit
Total cost 237 GBP Inc. VAT
2) Membranes
Zirfon membrane material, 60 pieces, each 20cmx20cm, total area 2.4m2, order 3m2 at 285 EUR per m2 = 3 x 285EUR
total cost 855 EUR or 747 GBP (check VAT)
3) Gaskets
EPDM Rubber 2mm thickness, 120 pieces, total area 4.8m2, order 5m2.
Total cost 59.16 GBP inc. VAT
4) Balance tanks, plexiglass or PVC
200 GBP
5) Fixtures, hoses, push connectors, pressure release valves etc
300 GBP
6) End walls, plexiglass
30 GBP
7) 8mm Stainless steel threaded rod x 8 and bolts
40 GBP
Total: 1,613 GBP

Contingency 10% 161 GBP:
1,774 GBP
NOTE:
Zirfon does not permeate hydrogen up to 80psi. Electrolyser will not run above this pressure.
If nylon silk screen mesh membranes can be used instead of Zirfon, substantial (approximately 70%) savings can be made in membrane costs. I will be doing further tests on viability, however, other mesh material is not expected to offer similar thresholds of gas permeability at similar pressures.

Figure 62. Electrolyser budget and specification

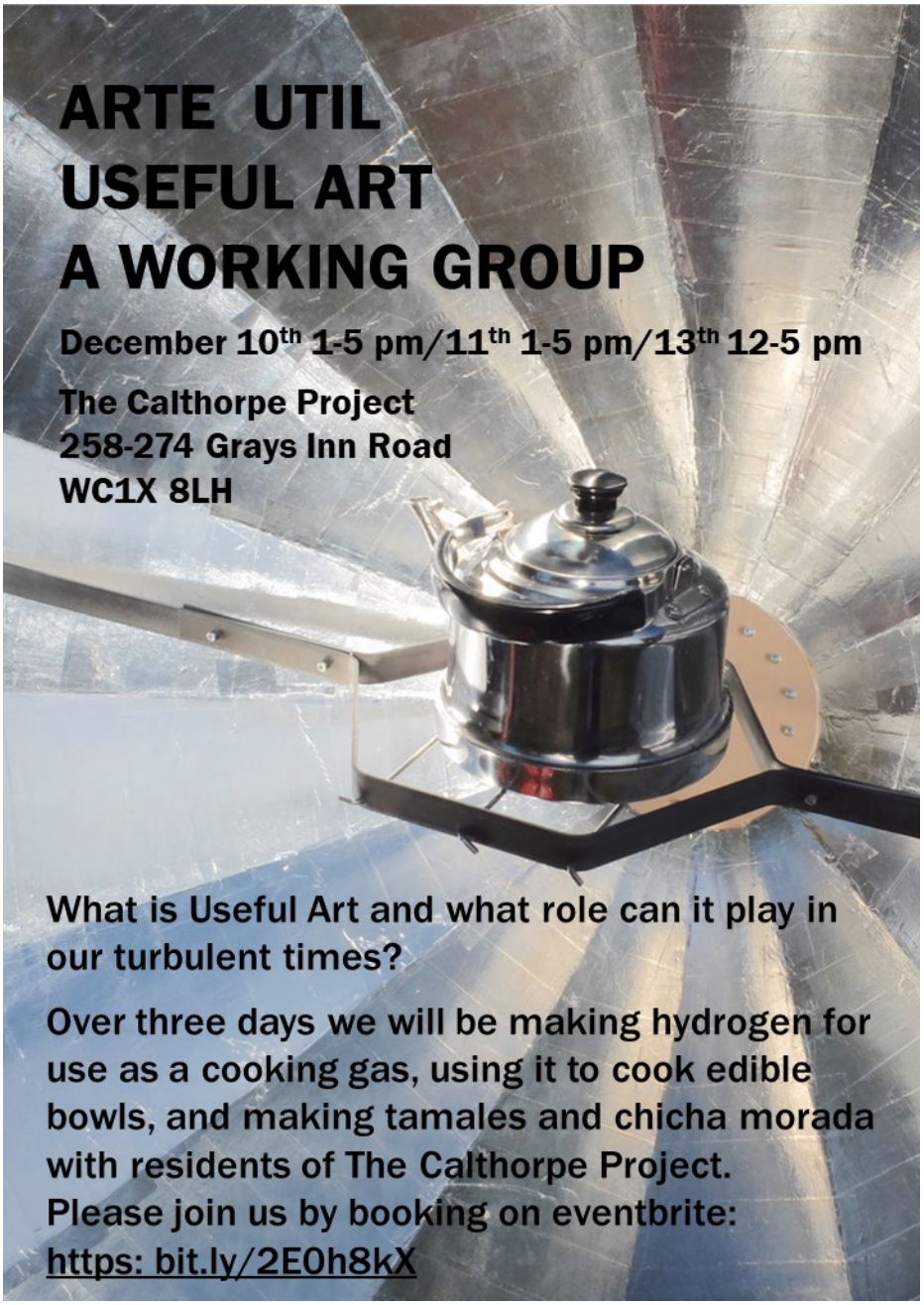

Figure 63. Arte Util/Useful Art workshop poster with PhD colleagues Ellie Doney and Kasia Depta-Garapich at the Calthorpe Project, Kings Cross, London December 2018

Figure 64. Dr Charlie Dunnill's hydrogen electrolyser in Swansea, Photo Nick Laessing

Figure 65. Dr Charlie Dunnill's Hydrogen Bike, photo Charlie Dunnill

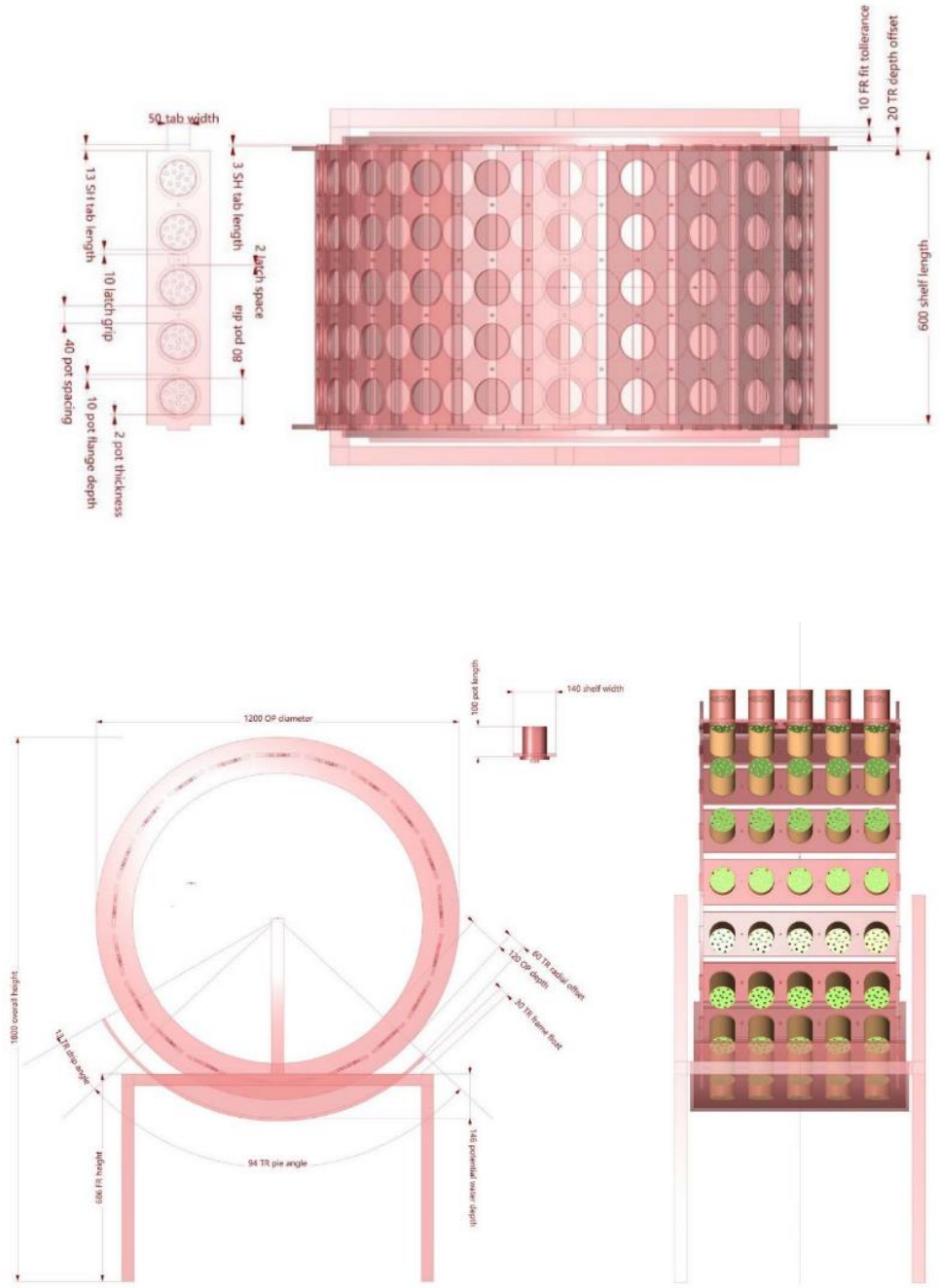

Figure 66. *Plant Orbiter 2017*. Technical CAD drawing and fabrication assistance Richard Simpson, fabrication assistance Rodrigo Arteaga, plexiglass laser cutting K2 plastics, Cambridge. Drawings by Richard Simpson.

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U.S. Department of Justice
National Drug Intelligence Center
Ohio HIDTA Drug Market Analysis 2010

Production

Local indoor marijuana production is increasing in parts of the HIDTA region, including Fairfield, Lucas, and Summit Counties, according to anecdotal law enforcement reporting. As a result of increased demand for high-potency marijuana, most indoor cannabis grow operators in the HIDTA region use hydroponic equipment and techniques for watering, ventilation, and lighting to support the production of high-potency marijuana. (See text box.) Independent Caucasian producers conduct most indoor cultivation in the HIDTA region, typically in private residences, and in other locations such as outbuildings and warehouses. For example, law enforcement officials in Cleveland report that most indoor grows in their jurisdiction are located in warehouses. Outdoor marijuana production also takes place in the HIDTA region to a limited extent, particularly in rural areas. Outdoor cannabis grow site operators occasionally use techniques designed to prevent detection by law enforcement, including planting several small plots rather than a single large site.

Rotary Garden Machine Seized From Youngstown Indoor Grow Operation

On January 6, 2010, officials with the Mahoning Valley Law Enforcement Task Force executed a search warrant on a private residence in Youngstown where the entire second floor of the residence was used solely for operating an indoor cannabis grow operation. A total of 255 cannabis plants were seized at the residence, along with a machine that contained approximately 140 of the seized plants. It was determined that the machine was a rotary garden machine, capable of holding 300 plants when filled to capacity. The entire cylinder of the machine rotated hourly, keeping the plants exposed to a high-intensity light source and fertilized water, producing high-potency marijuana.

Rotary garden machine

Interior of machine

Source: Mahoning Valley Law Enforcement Task Force.

One-Pot, or "Shake and Bake," Methamphetamine Production

A one-pot cook is actually a variation of the anhydrous ammonia method of production; however, in the one-pot method, cooks use a combination of commonly available chemicals to synthesize the anhydrous ammonia essential for methamphetamine production. In doing so, they are able to produce the drug in approximately 30 minutes at nearly any location by mixing ingredients in easily found containers, such as a 2-liter plastic soda bottle, as opposed to using other methods that require hours to heat ingredients on a stove, a process that could result in toxic fumes, primarily from the anhydrous ammonia. Producers often use the one-pot cook while traveling in vehicles and dispose of waste components along roadsides. Discarded plastic bottles may carry residual chemicals that can be toxic, explosive, or flammable.

Local small-scale methamphetamine production for personal use or distribution to a small network of individuals is rising in the HIDTA region. The number of methamphetamine laboratories seized by law enforcement officials in the HIDTA region increased approximately 41 percent from 2008 (39) to 2009 (55). (See Table 3.) This rise in laboratory seizures is attributed to increased use of the "one-pot" production method, a variation of the "Shake and Bake" method (see text box above), and to pseudoephedrine smurfing. Pseudoephedrine obtained through smurfing throughout the HIDTA region is typically sold to local methamphetamine producers for cash. In Fairfield County, pseudoephedrine is used as a form of payment for locally produced methamphetamine.

Table 3. Methamphetamine Laboratory Seizures, by County, Ohio HIDTA, 2005-2009

Figure 67 Rotary plant system for marijuana production seized by Ohio police department, 2010 Production and Transportation - Ohio HIDTA Drug Market Analysis 2010 (UNCLASSIFIED)," accessed April 23, 2021, https://www.justice.gov/archive/ndic/pubs40/40397/product.htm.

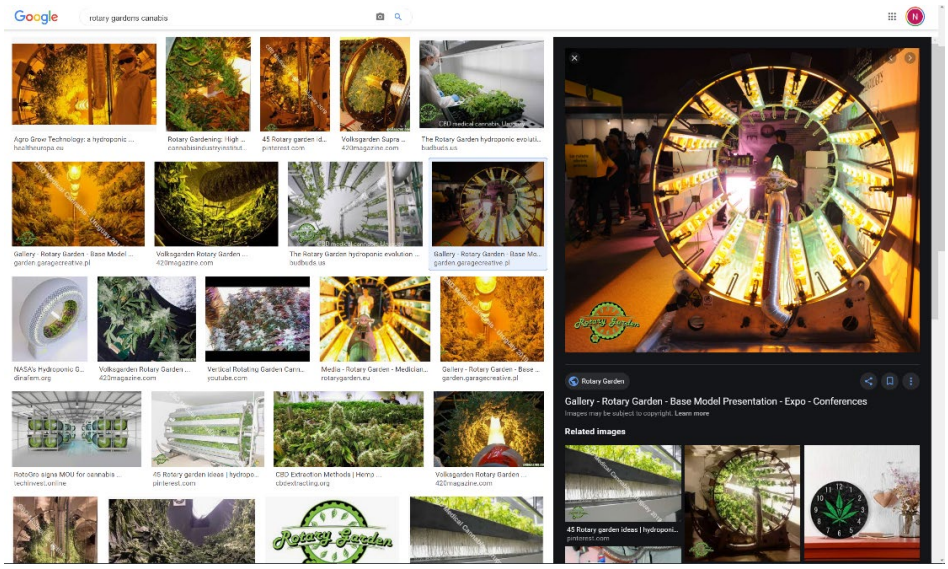
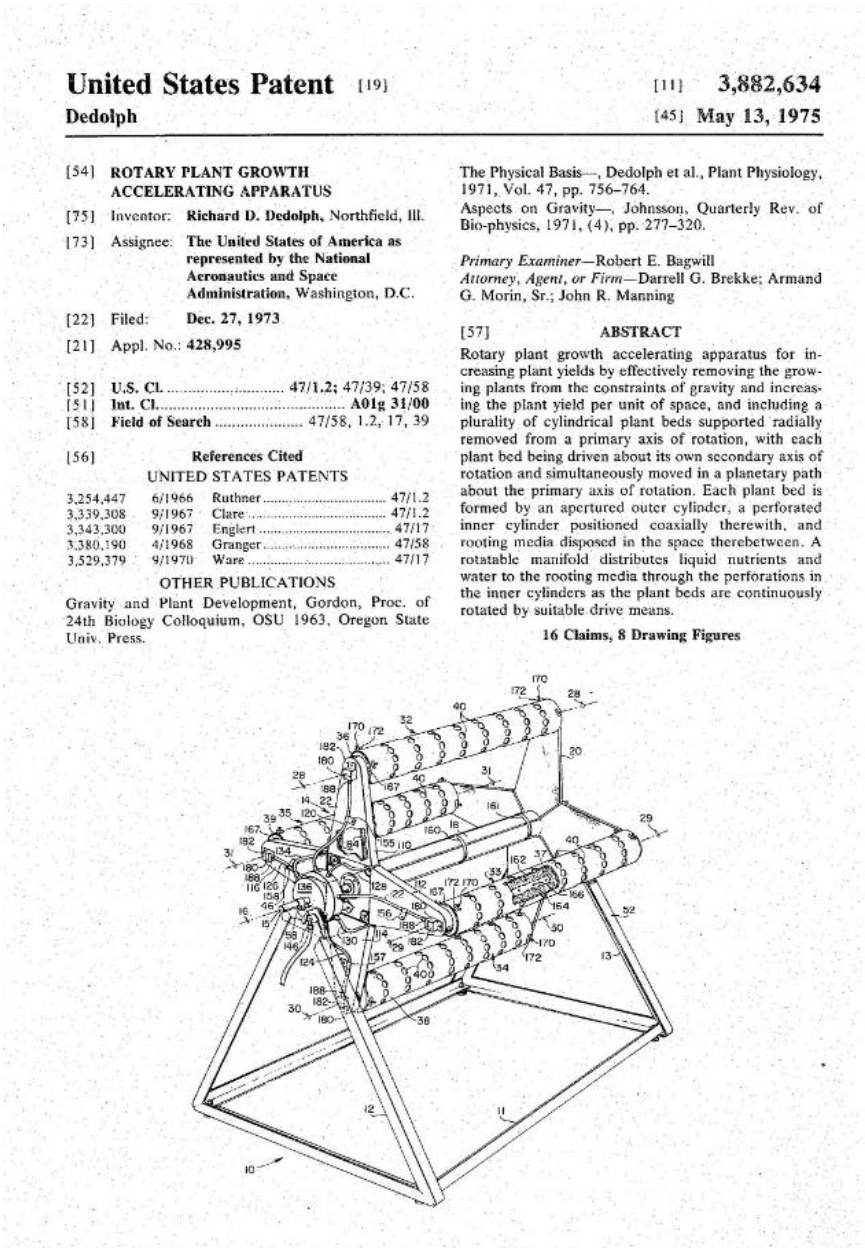


Figure 68. Google search for 'rotary cannabis garden'



United States Patent [19]
Dedolph

[11] **3,882,634**
[45] **May 13, 1975**

[54] **ROTARY PLANT GROWTH ACCELERATING APPARATUS**

[75] Inventor: **Richard D. Dedolph**, Northfield, Ill.

[73] Assignee: **The United States of America as represented by the National Aeronautics and Space Administration**, Washington, D.C.

[22] Filed: **Dec. 27, 1973**

[21] Appl. No.: **428,995**

[52] **U.S. Cl.** 47/1.2; 47/39; 47/58
[51] **Int. Cl.** **A01g 31/00**
[58] **Field of Search** 47/58, 1.2, 17, 39

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Primary Examiner—Robert E. Bagwill
Attorney, Agent, or Firm—Darrell G. Brekke; Armand G. Morin, Sr.; John R. Manning

[57] **ABSTRACT**

Rotary plant growth accelerating apparatus for increasing plant yields by effectively removing the growing plants from the constraints of gravity and increasing the plant yield per unit of space, and including a plurality of cylindrical plant beds supported radially removed from a primary axis of rotation, with each plant bed being driven about its own secondary axis of rotation and simultaneously moved in a planetary path about the primary axis of rotation. Each plant bed is formed by an apertured outer cylinder, a perforated inner cylinder positioned coaxially therewith, and rooting media disposed in the space therebetween. A rotatable manifold distributes liquid nutrients and water to the rooting media through the perforations in the inner cylinders as the plant beds are continuously rotated by suitable drive means.

16 Claims, 8 Drawing Figures

Figure 69. NASA patent for rotary plant growing device
Patent US3882634 - Rotary plant growth accelerating apparatus [Internet]. Google Books. 2018 [cited 13 February 2018]. Available from: https://www.google.com/patents/US3882634

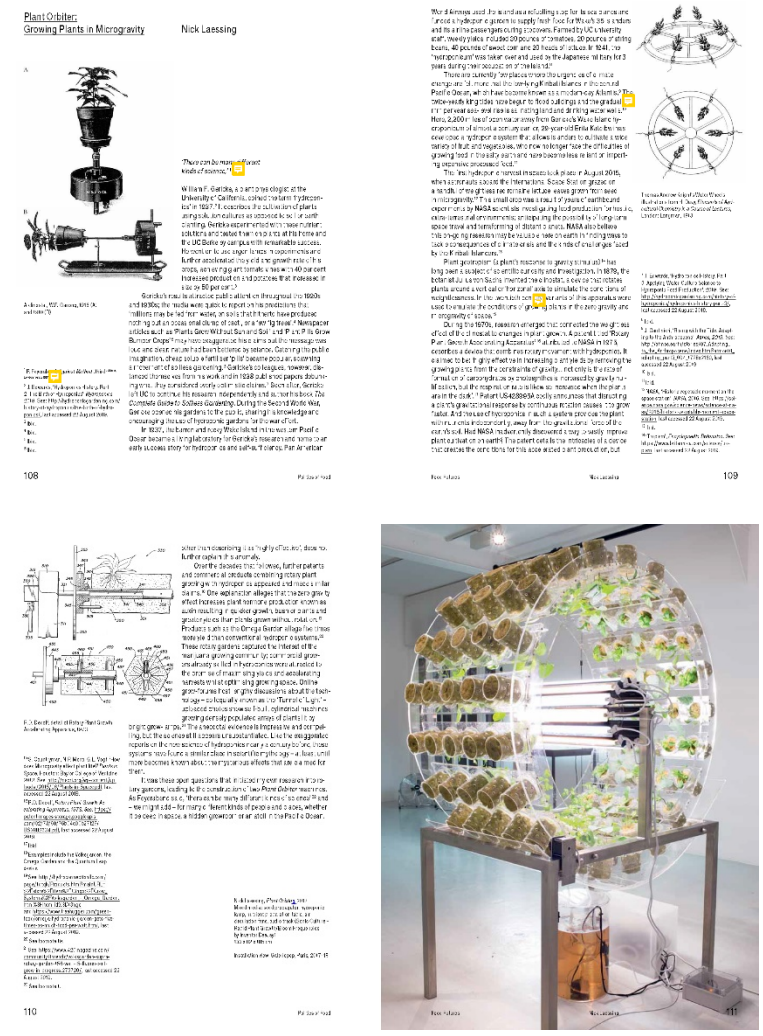

Figure 70. Politics of food 2019 publication.
Politics of Food, Dani Burrows, Aaron Cesar, Eds (Sternberg Press Delfina Foundation, 2019).