Makeshift Engineering: Practicing the craft of locally manufactured small wind turbines

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Definition

makeshift

/ˈmeɪkʃɪft/

adjective & *noun*

1. acting as an interim and temporary measure.

   synonyms: temporary, make-do, provisional, stopgap, standby, rough and ready, substitute, emergency, improvised, ad hoc, impromptu, extemporary, extempore, thrown together, cobbled together; jury-rigged, jury; *informal* quick and dirty

Non-intentional design - ‘Design by Use: The Everyday Metamorphosis of Things’ (Brandes, 2009)

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Concepts – Constructing the fluid, the shifty and the non-intentional

- **Social Construction of Technology – Development-in-use**
  "New meanings were given to the Model T by technically competent farm men. The car, as well as being a form of transport, could be a farm tool, a stationary source of power or part of a domestic technology." (Kline and Pinch, 1996 - 'Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States)
- **Incomplete Objects and Shiftspaces – Everyday shifts**
  Early moderns 'made use of' open-ended objects to a great variety of serviceable ends, which were called 'shifts'. 'Shiftspaces' are sites dedicated to the improvised, the open-ended and the shifty (Werrett, 2019,'Thrifty Science: Materials, Sustainability and the History of Experiments')
- **Non-Intentional Design – The attitude of the makeshift**
  Implies transformation, arises from temporary situations, describes what people do spontaneously, generates meaning through use (Brandes, 2009, 'Design by Use: The Everyday Metamorphosis of Things')
- **Fluidity of objects – Technical resilience through adaptive design**
  "An object that isn't too rigorously bounded (…) that is adaptable, flexible and responsive - in short, a fluid object - may well prove to be stronger than one which is firm" (De Laet and Mol, 2000 - 'The Zimbabwe Bush Pump: Mechanics of a Fluid Technology')

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Concepts – The evolution of peer-innovation in niches of experimentation

- **Proximal Design – Crafting tools for everyday needs**
  Characterized by: Constraining environment, Inventiveness by necessity, Flexible construction principles, Personalization and symbolic meaning, Social embeddedness, Sustainable practices (Usenyuk et al., 2016 - 'Proximal Design: Users as Designers of Mobility in the Russian North')
- **Dispersed Peer-Innovation – An evolutionary design process**
  Need recognition → Idea formulation → Development → Commercialization / Diffusion → Adaptation-in-use (Hyysalo and Usenyuk, 2015 - 'The User Dominated Technology Era: Dynamics of Dispersed Peer-Innovation')
- **Grassroots Sustainability Innovations – Niches of experimentation**
  "A 'global' niche reflects a network that connects together a range of different actors who are developing similar experimental technologies and provides a mechanism by which information sharing and collaboration is facilitated". (Longhurst, 2012 - 'The Totnes Pound: A Grassroots Technological Niche')
- **Design Global, Manufacture Local – Commons-based peer production**
  "The processes through which a design is developed, shared and improved as a global digital commons, whereas the actual manufacturing takes place locally through shared infrastructures." (Kostakis et al., 2015 - 'Design Global, Manufacture Local: Exploring the Contours of an Emerging Productive Model')

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Methodology – **Biographies of Technologies and Practices (BoTP)**

A combination of historical and ethnographic investigation into the technology and related practices. (Hyysalo, 2010 - ‘Health Technology Development and Use’)

Historiography*:* Several historical episodes which overlap or feed into each other

- Episode 1: Off-grid rural electrification in the US (1916-1947)
- Episode 2: The Alternative Technology movement in the UK (1968-2001)
- Episode 3: Commercialization of off-grid electrification systems using renewable energy resources (1987-2009)
- Episode 4: Globalization and the Internet (1998-2011)
- Episode 5: Maker culture and the Design Global, Manufacture Local production model (2006-current)

Ethnography*:* Field trips to Scoraig, Scotland in 2012, 2015, 2017: Interviews recorded in audio recordings, participant observation and interaction, field diaries and sketches, photos and videos.

Methodology – **Participatory Action Research**

"Action research is a participatory process concerned with developing practical knowledge. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people." (Reason and Bradbury, 2008 - 'The SAGE Handbook of Action Research: Participative Inquiry and Practice')

- Involved in the **Wind Empowerment executive board** (2013-current) and the organizational committees for three conferences WEAthens2014, WEPatagonia2016, WEIndia2018.
- Conducted **rural electrification projects** using locally manufactured small wind turbines in Greece (2013), Ethiopia (2015), Nepal (2017) and South Africa (2018).
- Delivered **adult education** practical courses in Greece on locally manufactured small wind turbines with the School of the Earth (2010-current).
- Participated in university **student education** in Greece on locally manufactured small wind turbines with the RurERG at the National Technical University of Athens (2010-current).

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Focus – Engineering Design Cultures

Makeshift Engineering as a crafts-based engineering design process (or attitude)

- "The work of designers is ruled by implicit elements that interact in a particular way - that is, by a **culture of design**." (Vinck, 2003 - 'Everyday Engineering: An Ethnography of Design and Innovation')
- "Pre-modern **technicians (craftsmen and engineers)** extrapolated experiential knowledge from empirical observation of what worked within a given set of material circumstances and practices." (Epstein, 2018 - 'Transferring Technical Knowledge and Innovating in Europe, c.1200-1800')
- "Craft involves **thinking during making**." (Aitchison, 2017 - 'Craft Thinking & Digital Making: The role of the architect in the digital era')
- "Craft creates **intimate relations** between problem solving and problem finding, technique and expression, play and work." (Sennett, 2008 - 'The Craftsman')
- "Craft as a way of thinking through the material can be incorporated into **practice-led design research**." (Nimkulrat, 2012 - 'Hands-on Intellect: Integrating Craft Practice into Design Research')

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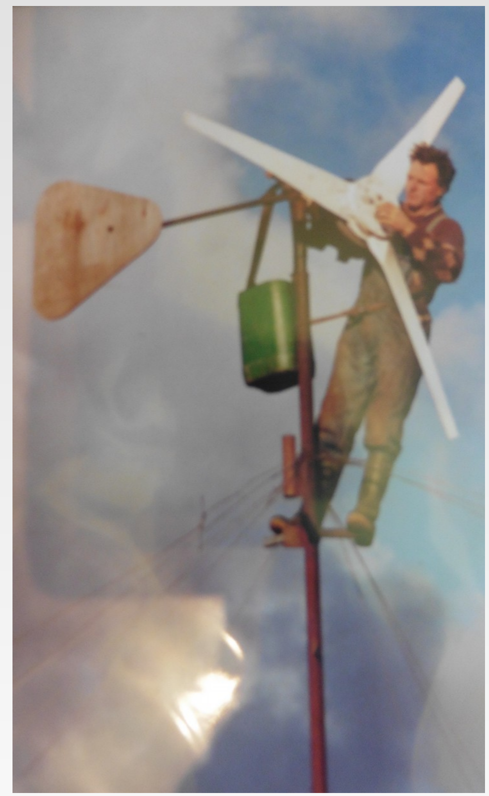
Macro-scale view of historical episodes in the fractal evolution of grassroots technological networks of locally manufactured small wind turbines and their stages of development:

Shared **vision** → technical **challenge** → available **resources** → spaces of **communication** → technology **development** → **reference** design → network **expansion**

Rural Electrification in the US: Farmers constructed small wind electric plants from Ford's Model T parts using popular manuals (1924-1942)

Alternative Technology in the UK: Back-to-the-land pioneers refurbished old wind chargers and built windmills from Austin Champ parts (1979-1993)



Commercialization of renewable energy systems: Available components (electronics, batteries, magnets) allowed up-scaling of windmills (1993-2001)

The Internet, Globalization and Maker Culture: Digital P2P communication facilitated the growth of global networks of SWT technicians (2001-current)

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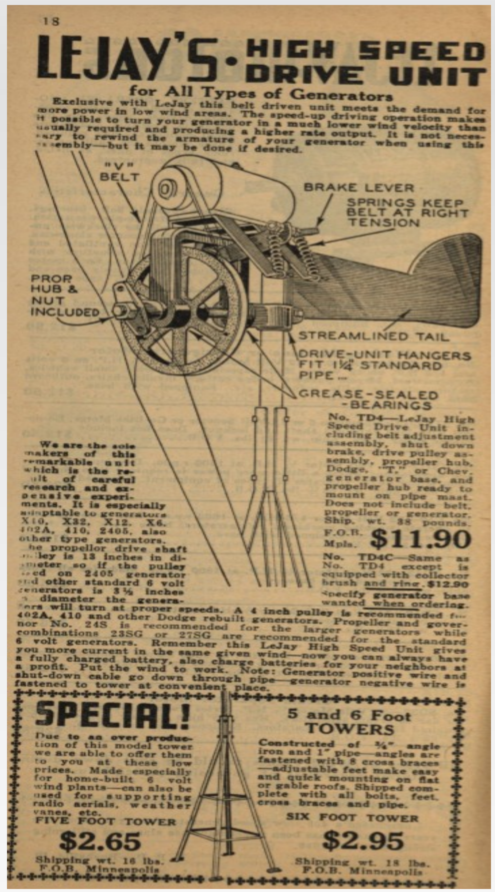
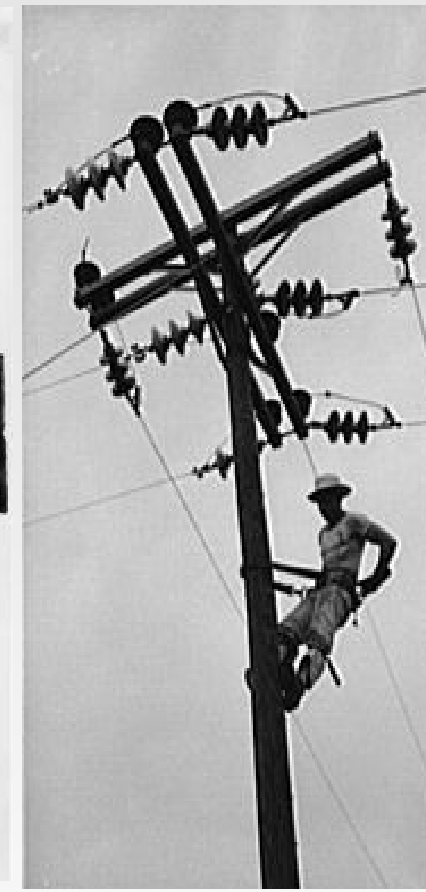
1930s – Locally manufactured wind chargers electrifying rural farms in the US

Young farmers built wind chargers for powering home made radio sets, using Model T parts (dynamos, batteries etc) and propeller type blades.



The LeJay Manual consisted of Do-It-Yourself plans for making wind chargers among other devices such as electric welders and other power tools.

Young farmers such as the Jacobs brothers and the Albers brothers commercialized their wind turbine designs installing more than 400,000 units.



The Rural Electrification Act in 1936, under the New Deal, provided federal loans for the installation of electrical distribution systems.

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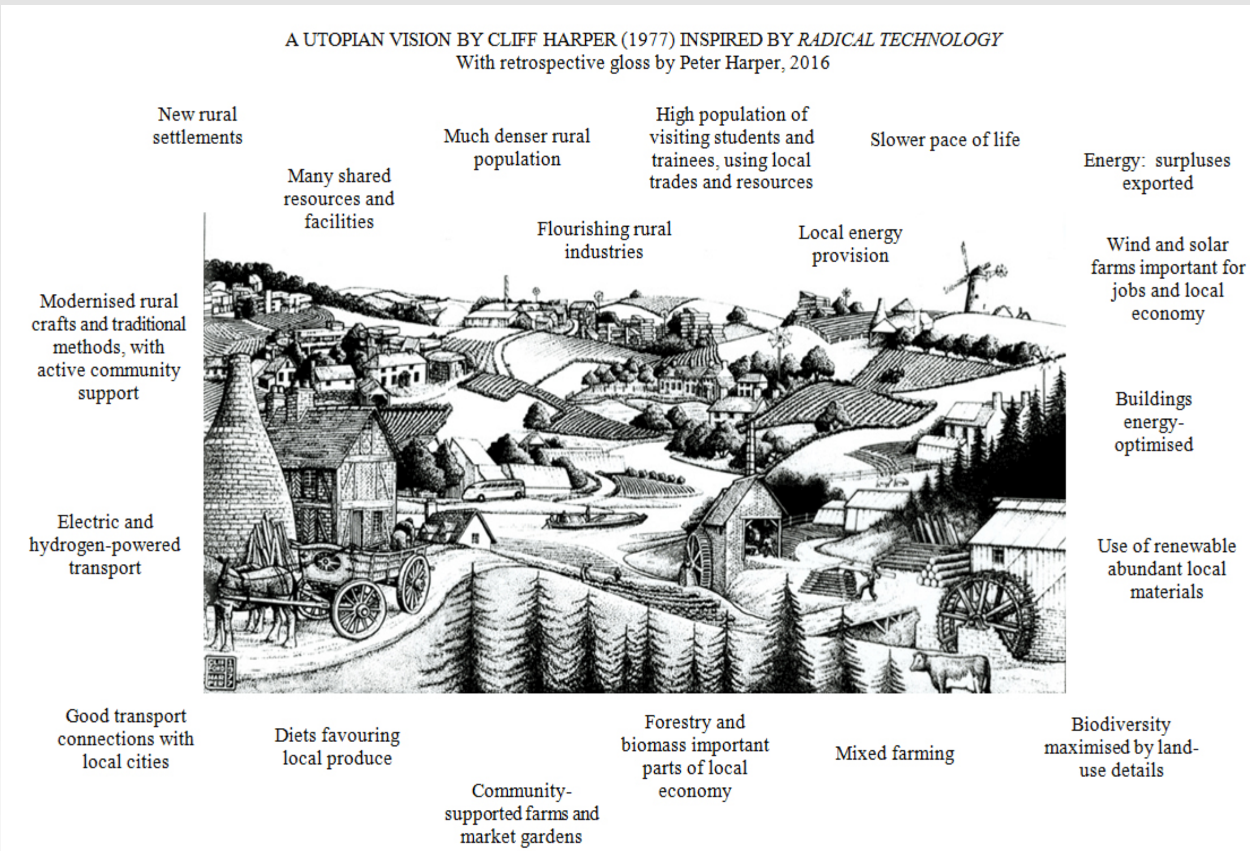
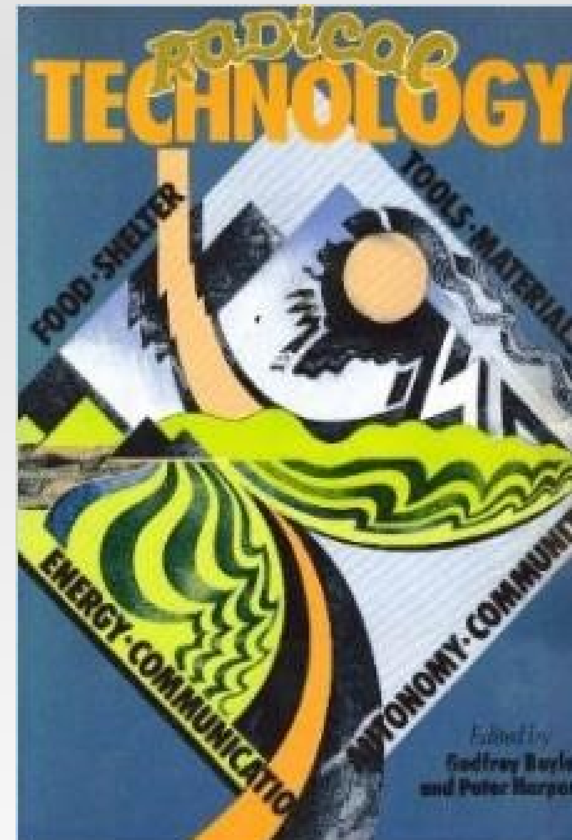
1970s – Alternative Technology movement in the UK (Vision)





1970s: The Alternative Technology movement in the UK criticized the industrial-capitalist mode of production and cross-pollinated the counter-culture with ideas on ecology and low impact lifestyles, along with participatory politics based on the anarcho-utopian tradition.

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1970s – Small wind turbines for eco-communities (Challenge)

1972: The term ‘alternative technology’ was first used in the ‘Undercurrents’ magazine, a popular information hub.

1973: Young environmentalists initiated the Center for Alternative Technology (CAT) in Wales and experimented with wind energy.

1974: The first Community Technology (COMTEK) festival showcasing a bottom-up process of technological innovation.

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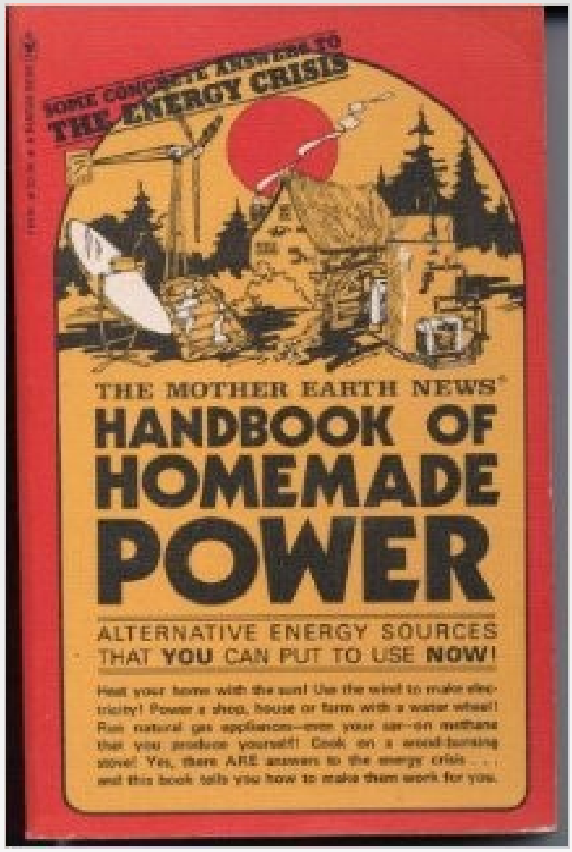
1980s – Electrifying the community of Scoraig in Scotland (Resources)



1978: Hugh Piggott went through seven prototype machines using a limited number of tools, and materials from the scrap yard.

1979: Using a Austin Champ 'Jeep' dynamo and 2-bladed wooden rotor to charge a 12V car battery to produce about 300W.

1981: More than 40 wind turbines could be seen on the skyline of the peninsula, and all provided fertile ground for experimentation

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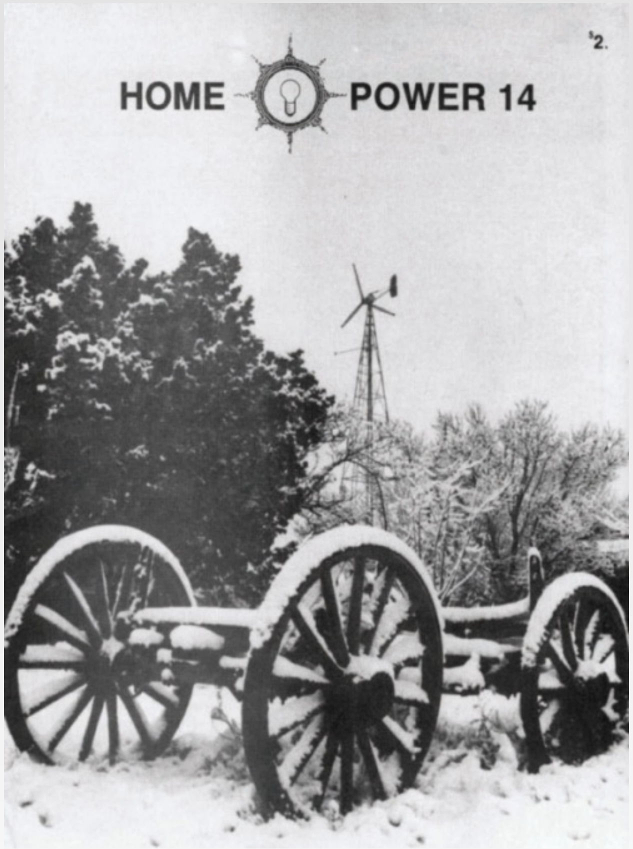
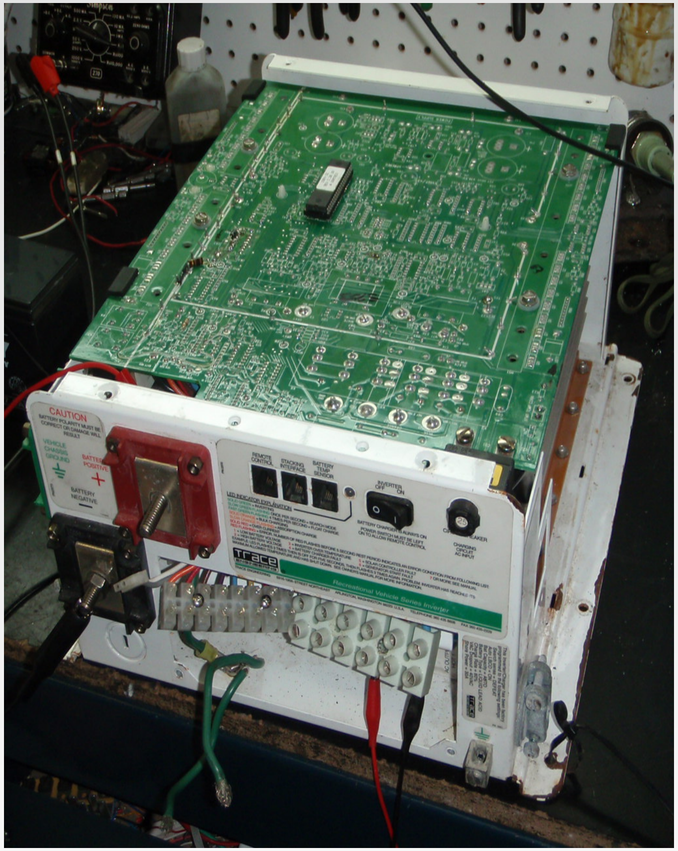
1990s – Commercilization of renewable energy off-grid system components



1987: The Home Power magazine in the US, promoted renewable energy and provided information on DIY home scale off-grid systems.



1984: Trace Engineering in the US was born with the goal to 'build inverters that wouldn't break'. By 1994 they had reliable designs.

Early 90s: Some commercial wind turbines (Bergey, Proven, LMW) were installed in Scoraig and tested alongside the locally manufactured technology.

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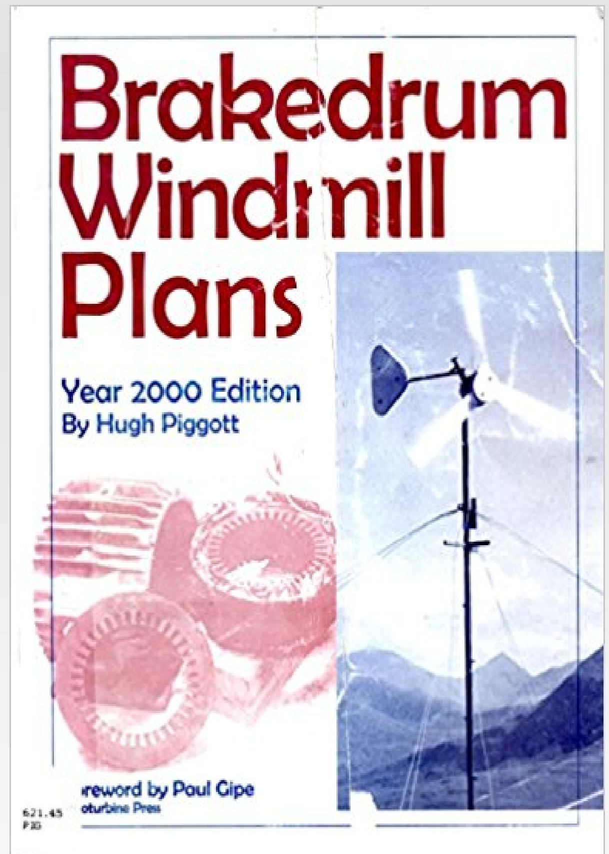
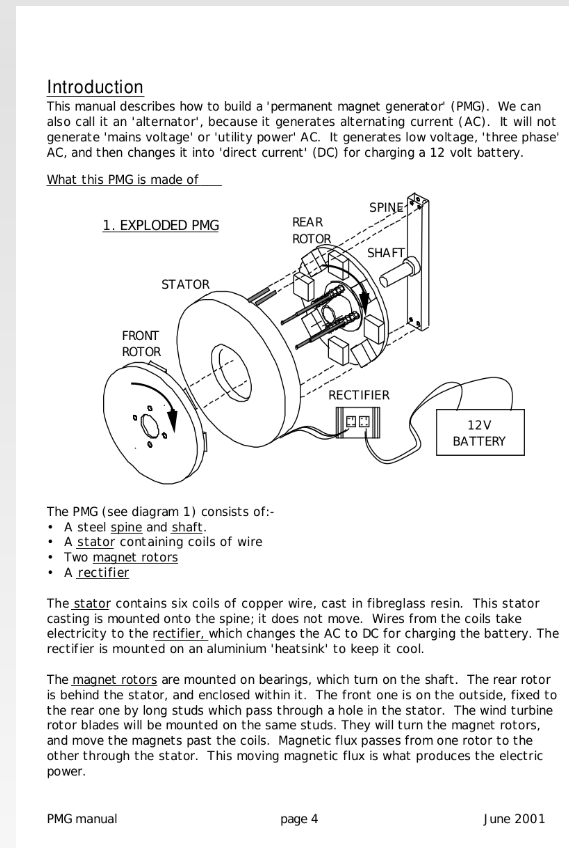
1990s – Do-It-Yourself (DIY) windmill plans (Communication)

1993: Ferrite magnets, which were becoming cheaper and more widely accessible, provided a new alternative to the dynamo.



1998: A self-publication selling at 1,000 copies per year through the new website, and creating a hype around DIY wind turbines.



Introduction

This manual describes how to build a 'permanent magnet generator' (PMG). We can also call it an 'alternator', because it generates alternating current (AC). It will not generate 'mains voltage' or 'utility power' AC. It generates low voltage, 'three phase' AC, and then changes it into 'direct current' (DC) for charging a 12 volt battery.

What this PMG is made of

The PMG (see diagram 1) consists of:-

- A steel spine and shaft.
- A stator containing coils of wire
- Two magnet rotors
- A rectifier

The stator contains six coils of copper wire, cast in fibreglass resin. This stator casting is mounted onto the spine; it does not move. Wires from the coils take electricity to the rectifier, which changes the AC to DC for charging the battery. The rectifier is mounted on an aluminium 'heatsink' to keep it cool.

The magnet rotors are mounted on bearings, which turn on the shaft. The rear rotor is behind the stator, and enclosed within it. The front one is on the outside, fixed to the rear one by long studs which pass through a hole in the stator. The wind turbine rotor blades will be mounted on the same studs. They will turn the magnet rotors, and move the magnets past the coils. Magnetic flux passes from one rotor to the other through the stator. This moving magnetic flux is what produces the electric power.

PMG manual page 4 June 2001

2001: The 'Permanent Magnet Generator (PMG): A manual for manufacturers and developers' was published for ITDG.

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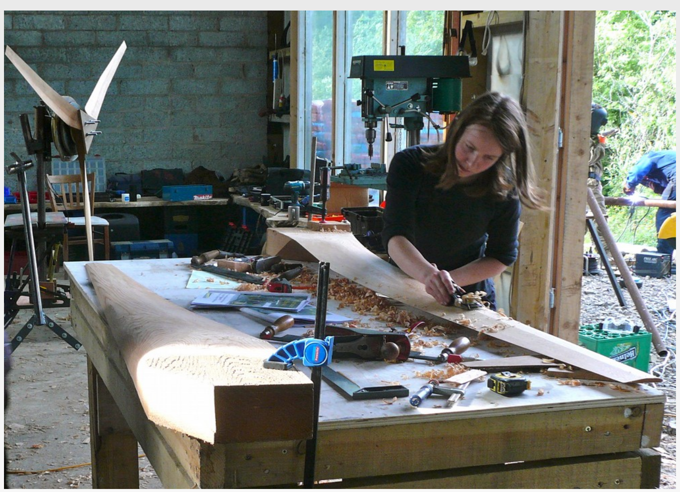
2000s – Axial Flux machines and construction courses (Development)







2003: After attending one of Hugh's courses, OtherPower set up the Fieldlines.com internet forum. Over the next years, the forum gathered more than 6,000 members and became one of the largest hubs of information sharing on DIY wind turbines.

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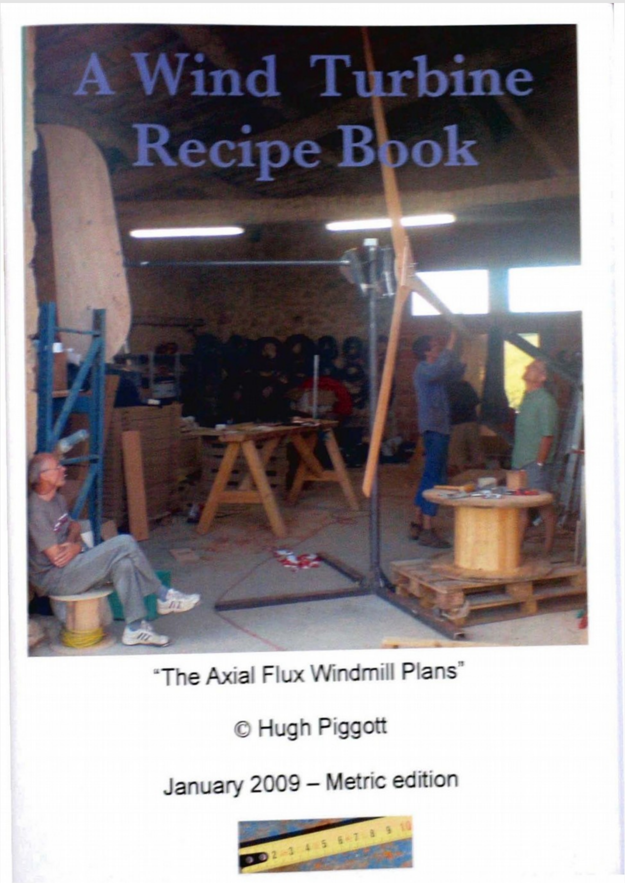
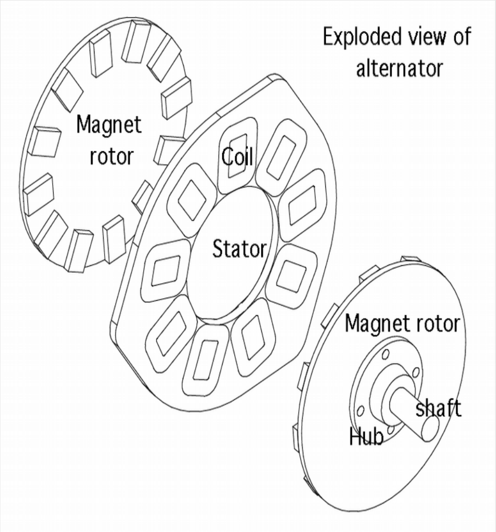
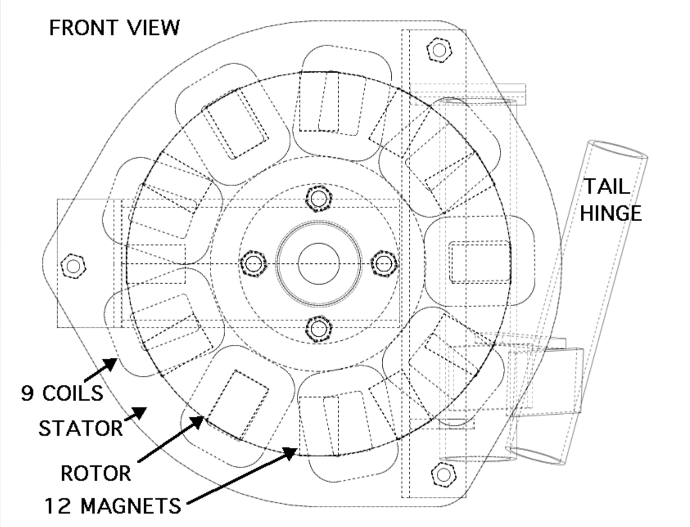
2000s – Wind Turbine Recipe Book (Reference)







Estimated monthly energy production at different mean windspeeds						
Turbine diameter mm	1200	1800	2400	3000	3600	4200
Power rating	200 W	350 W	700 W	800 W	1000 W	1000 W
Mean 3 m/s	5 kWh	12 kWh	22 kWh	34 kWh	49 kWh	67 kWh
Mean 4 m/s	14 kWh	30 kWh	54 kWh	85 kWh	122 kWh	166 kWh
Mean 5 m/s	23 kWh	53 kWh	93 kWh	146 kWh	210 kWh	286 kWh
Mean 6 m/s	33 kWh	74 kWh	131 kWh	205 kWh	296 kWh	402 kWh
Mean 7 m/s	41 kWh	92 kWh	164 kWh	256 kWh	369 kWh	502 kWh
Estimate cost of materials	£250	£350	£500	£600	£800	£1000

2009: Based on a previous version of 2005, the manual described a 'standardised' manufacturing process for a set of six windmills. The 'Recipe Book' was gradually finding its way in the toolbox of many local manufactures of wind turbines, who collectively over the years, had built, installed and tested more than 1000 wind turbines, creating a vast pool of common knowledge.

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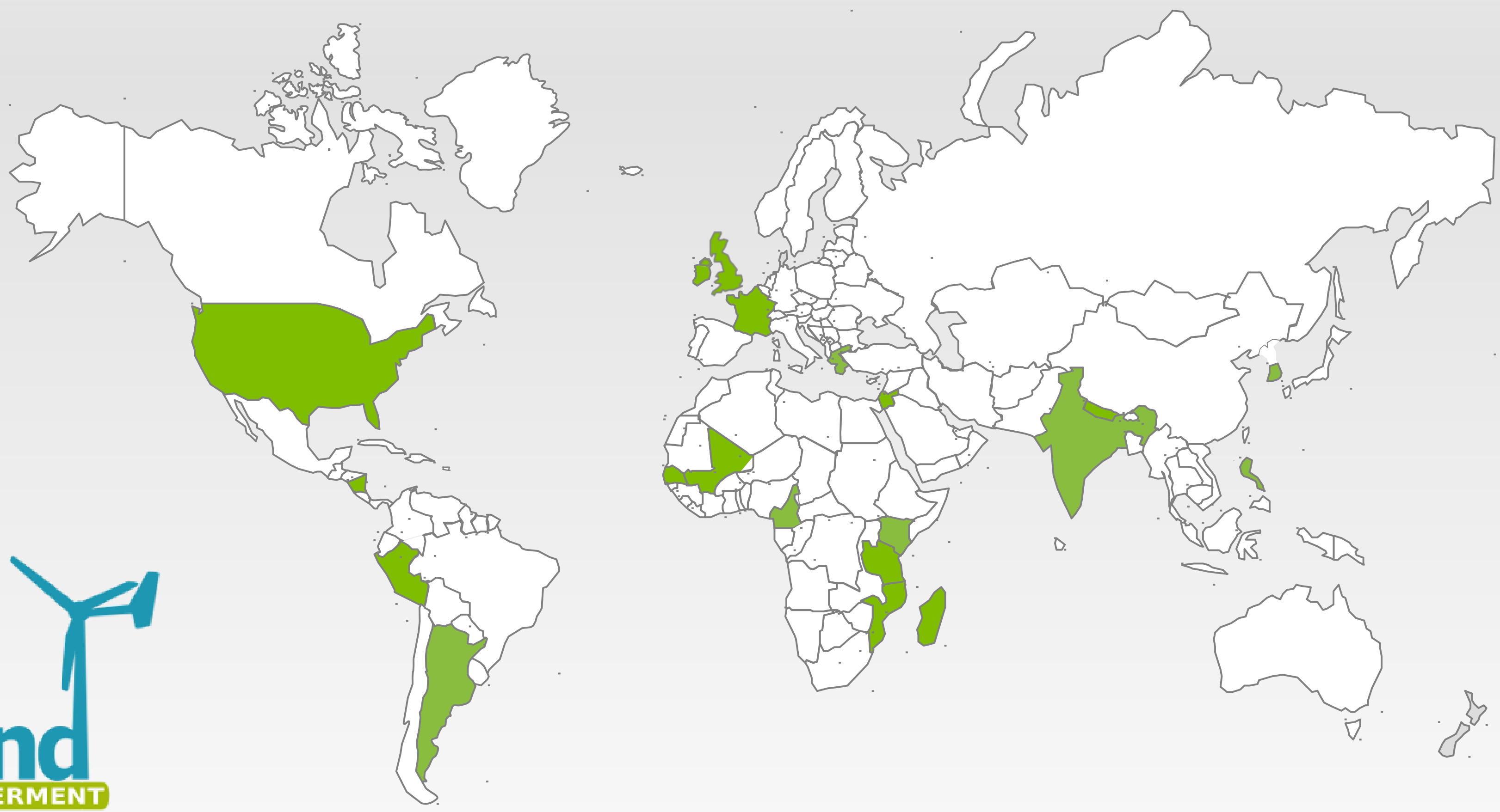
2010s – Wind Empowerment Association (Expansion)



2017: Six years since its birth in Dakar in 2011, the Wind Empowerment association had grown to include 56 organisations from 31 countries, operating now on most continents, and using a ‘Design Global Manufacture Local’ production model.

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Windmills of Scoraig – Organic relationship with the natural, social & material

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Cradle-to-cradle – Windmills spinning from the scrapyard to the junk pile




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Queer aesthetics – A patchwork of function, resources & temperaments

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Queer aesthetics – A patchwork of function, resources & temperaments

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Tweaking – Technical mutations for necessity, convenience, enjoyment

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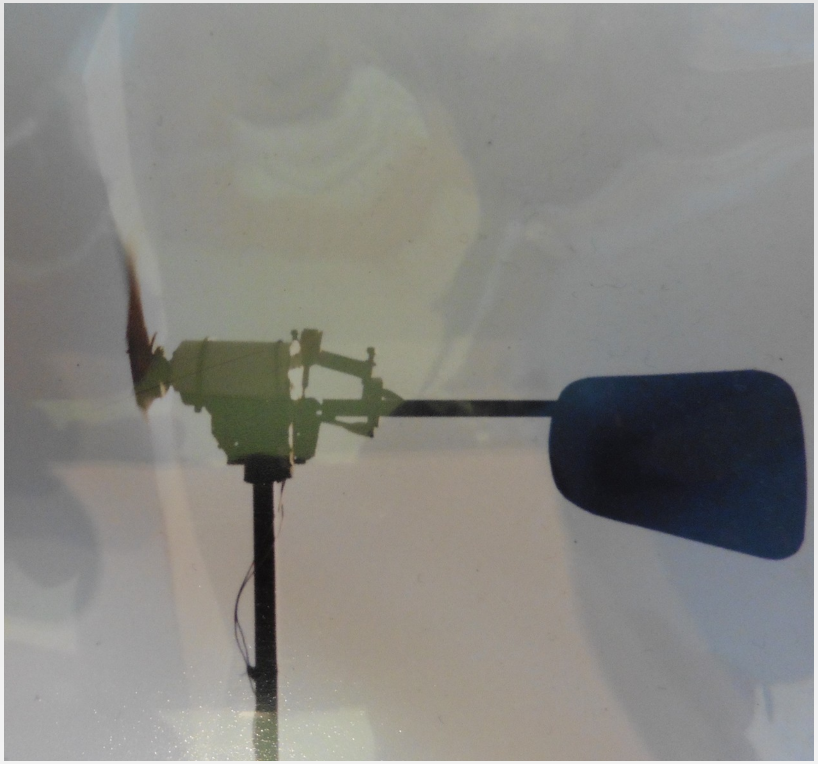
Recycling – Salvaged objects creating makeshift engineering ‘standards’



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Sourcing, Sharing and Styling – Materials, tools, skills and knowledge




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Hacking – Re-configuring commercial wind turbines into hybrid machines





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Experimenting – ‘High science, low technology’ and the rules of thumb





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Repairing and Maintaining – In relationship with machines and their temperament

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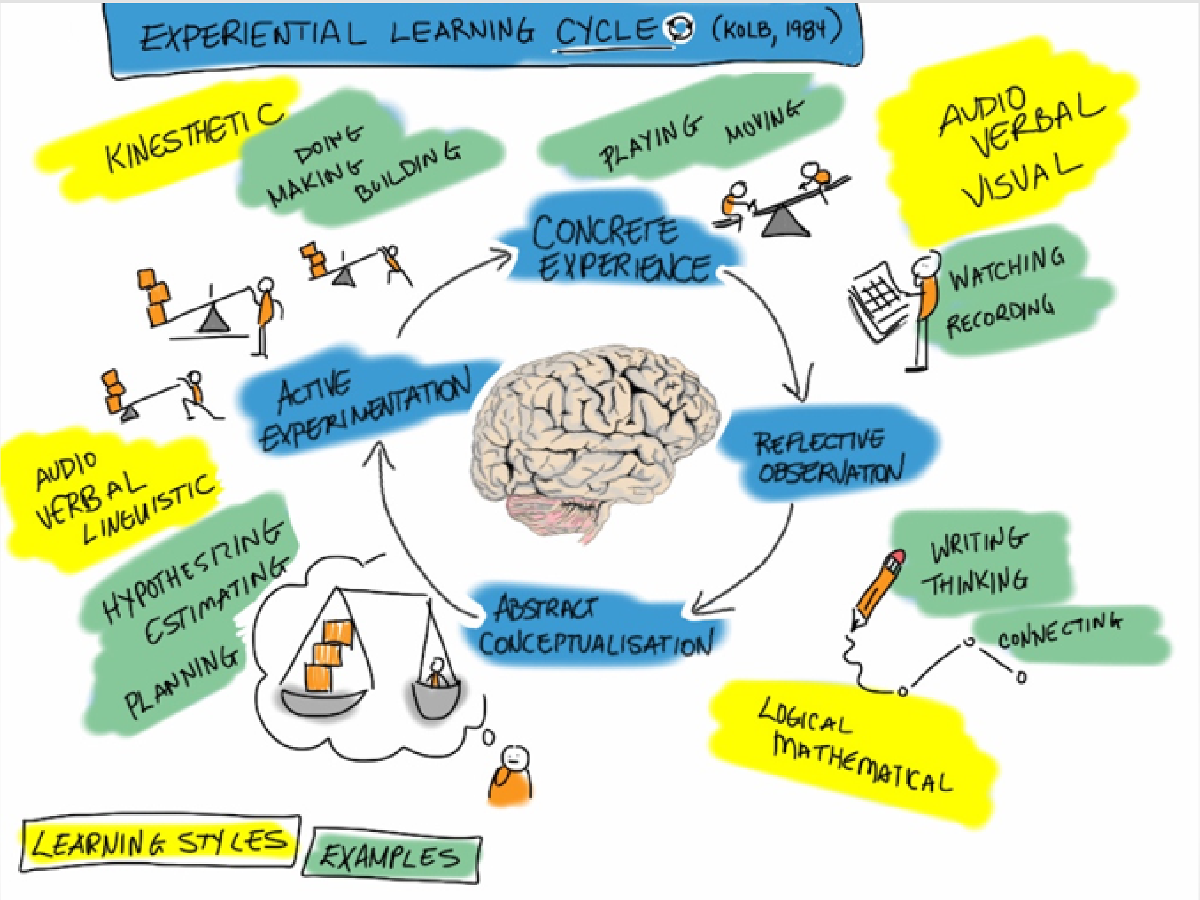
Mastering (the black art of wind turbine building) – From Makeshifts to Craft

"The way I do it is I start with the rotor diameter and the input shaft power (…) After that it gets very crude (...) In my experience the tail moment should be around 50-70% of the wind thrust moment. The blades have their own moments that is what makes all of this a black art (…) In the end much of it is about what worked last time and then allowing for the changes using theory as best I can within the limits of my understanding."

(Hugh Piggott, personal communication, October 2017)

Black art - A process that is mysterious or difficult to master



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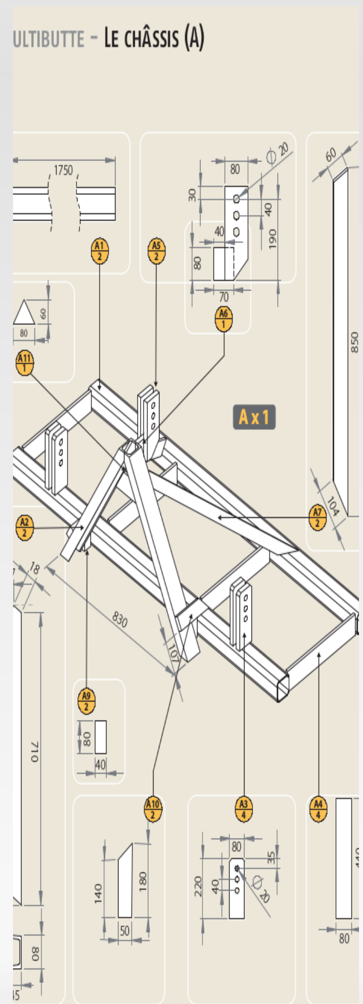
Tribes of Makers – L'Atelier Paysan: Farmers building agricultural equipment

L'atelier paysan
COOPÉRATIVE D'AUTOCONSTRUCTION



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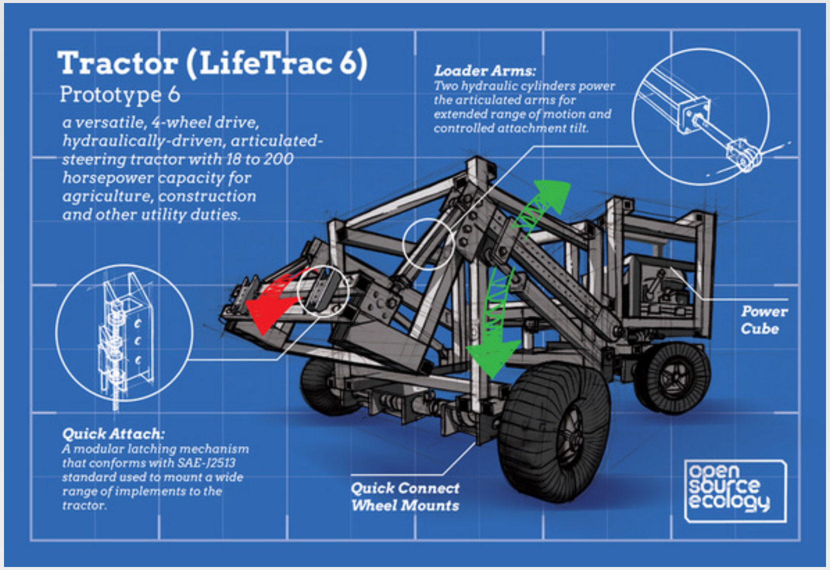
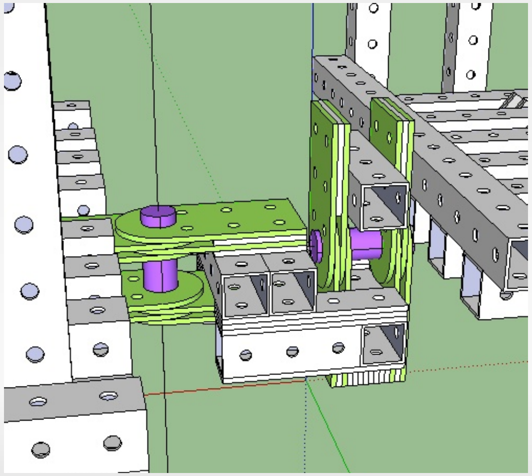
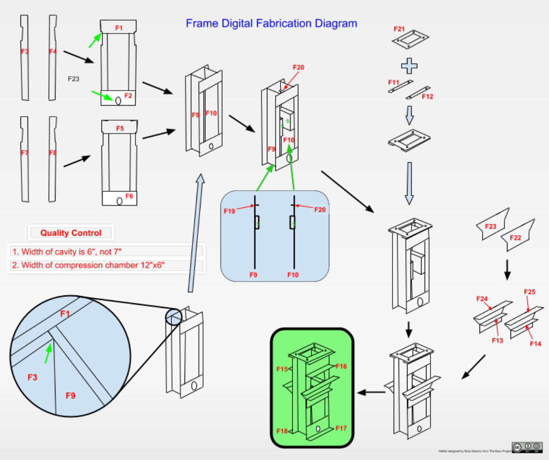
Tribes of Makers – Open Source Ecology & the Global Village Construction Set







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Tribes of Makers – Farm Hack: A global community of farmers

GET STARTED | TOOLS | CONVERSATIONS | CULTURE | CALENDAR | SHOPS | BLOG | Login | Register

FARM HACK

We are a worldwide community of farmers that build and modify our own tools. We share our hacks online and at meet ups because we become better farmers when we work together.

Watch our movie. Get started here.

SUITE OF PEDAL-POWERED GRAIN AND BEAN CLEANING TOOLS DOCUMENTED ON FARMHACK.ORG

Bicycle Powered Thresher

Tool Library + Add a tool

'FarmHack is a community for those who embrace the long-standing farm traditions of tinkering, inventing, fabricating, tweaking, and improving things that break.'

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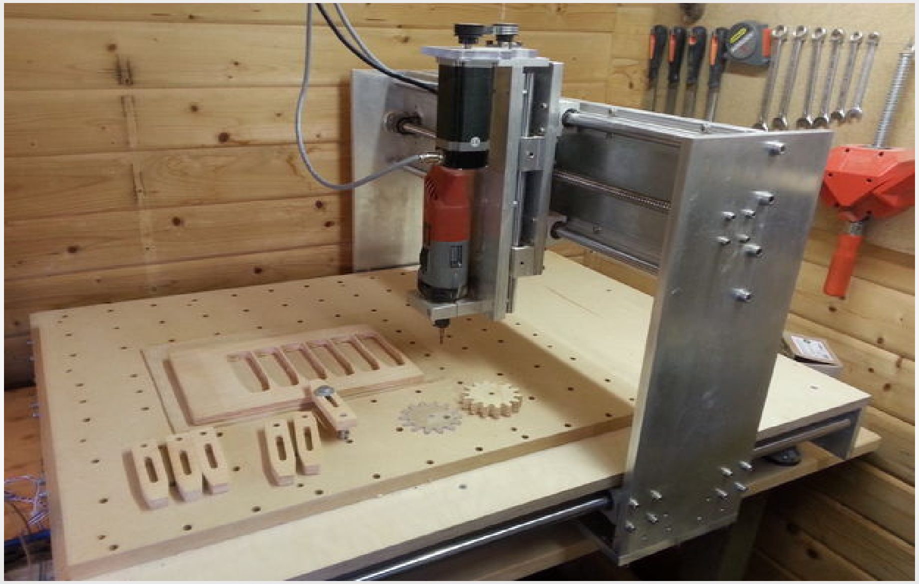
Tribes of Makers – Rapid growth of urban Hacker and Maker spaces



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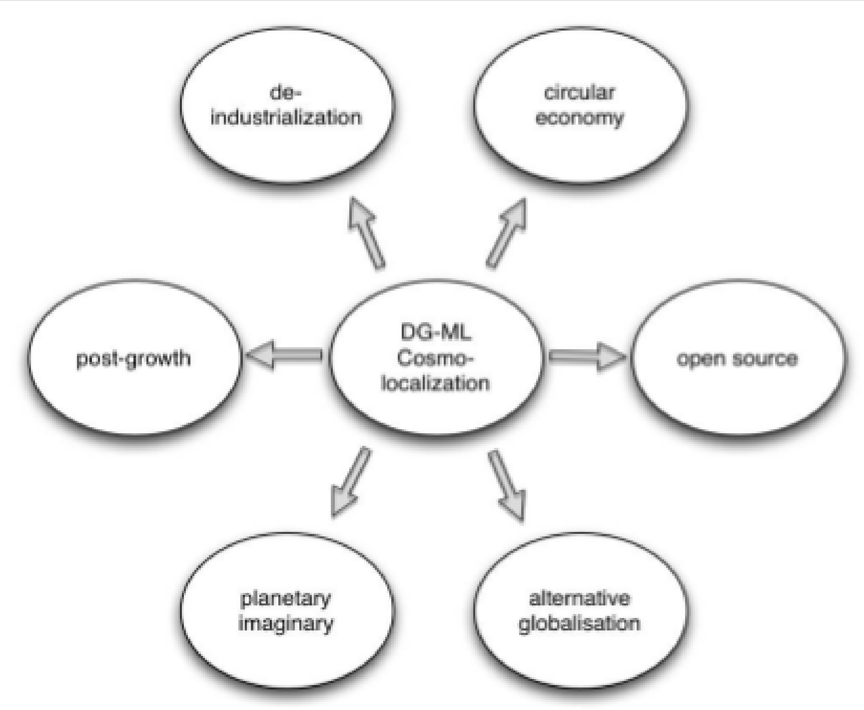
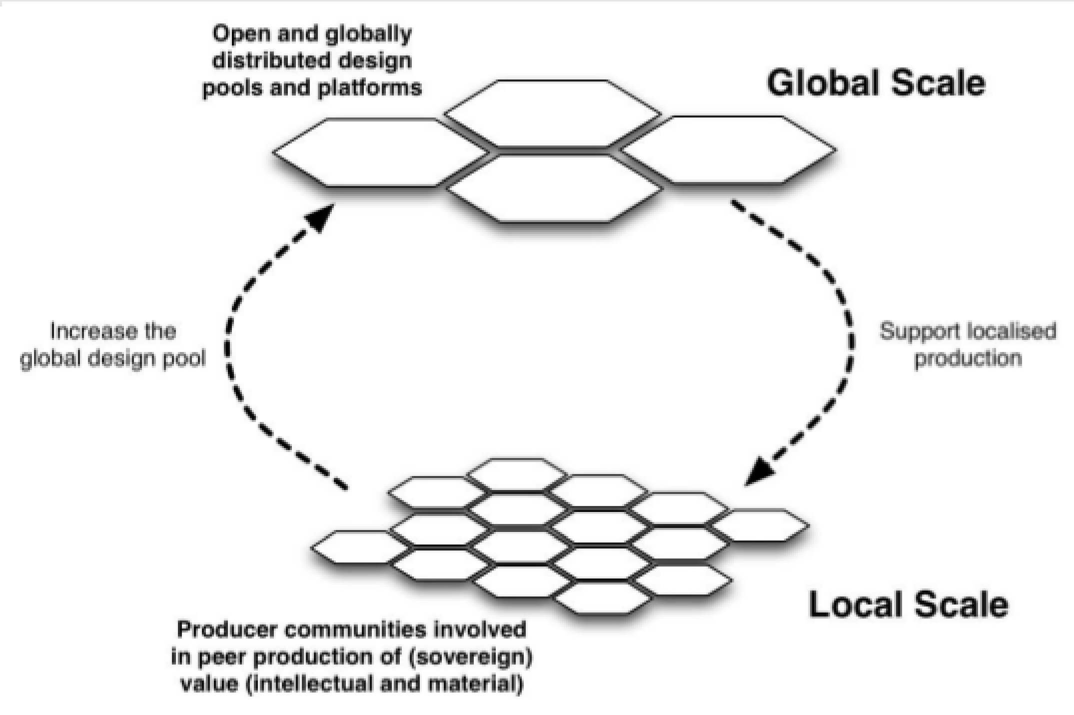
Design Global Manufacture Local: The cosmo-localization of D&M





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‘Makeshift Engineering’ design qualities – Crafting humble machines

- A makeshift is **incomplete**, always a work-in-progress – commercial machines claim to be complete and finalized.
- A makeshift has **temporary and localized** function – commercial machines claim to be universal and long-lasting.
- A makeshift is a **humble** machine – commercial machines aspire to dominate.
- A makeshift coexists in **relationship** with the user – commercial machines claim to be independent.
- In a failure, a makeshift **empowers** the user – a failed commercial machine disempowers and creates dependence.
- The life time of a makeshift engineered machine cannot be determined, as its parts are replaced constantly. In this sense such machines can be considered **timeless**.
- The makeshift displays technical **resilience** through recurring adaptation to changes in the environment.

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Thank you for your attention!

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