46° 'BENT – DESIGN, MANUFACTURE AND DEPLOYMENT OF DIY RECUMBENT BICYCLES

Andrew Last

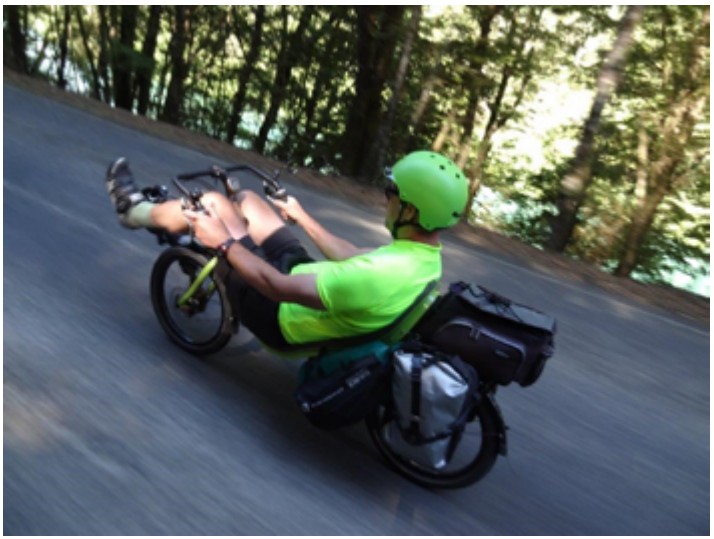

Figure 1. Andrew Last touring on *Recumbent #5*.

This article maps the evolution of my studio-based project developing a series of five recumbent bicycles primarily used as commuter transport. From a desire to experience the differences involved in recumbent cycling, without the expense of an untested purchase, there grew an obsession that has spanned five years to date. The project has drawn together related aspects of my various professional practices: I have sought to extend my metalsmithing craft; broaden my knowledge of learning strategies relevant to arts education; and experienced first-hand how riding a homemade bicycle may offer an effective critique of our society's unsustainable dependence on fossil-fuel transport.

The project had five key aims:

- to investigate the potential benefits of recumbent bicycle designs that challenge the market dominance of traditional diamond-frame bicycles
- to test the potential for producing viable DIY alternatives to mass-produced consumer bicycles
- to make use of internet communities as a source of information, learning and knowledge-sharing that offers a new mode of learning beyond traditional institutions or trade practices
- to use these unusual bicycles as a highly visible demonstration that cycle commuting is a viable alternative to fossil fuel-dependent transport and
- to examine the potential of the bicycle to function as a political catalyst to push toward a more sustainable society

MY EXPERIMENTS WITH RECUMBENT BICYCLES

In common with most suburban Melbourne boys growing up in the 1970s, my first bike (at age 7) was a dragster with a banana seat, sissy bar and ape-hanger handlebars (Figure 2).Eventually, I modified the dragster to become a much cooler proto-BMX (Figure 3).

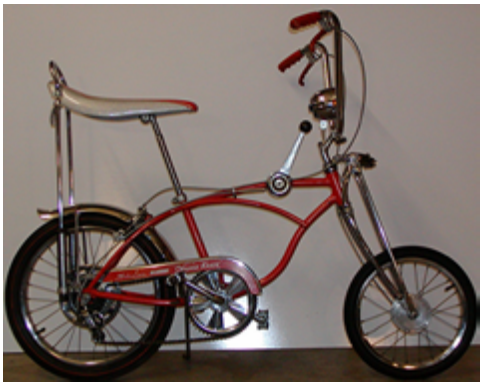

Figure 2. Schwinn Dragster. Photograph: Nels P Olsen, Creative Commons Attribution-Share Alike 2.0 Generic.

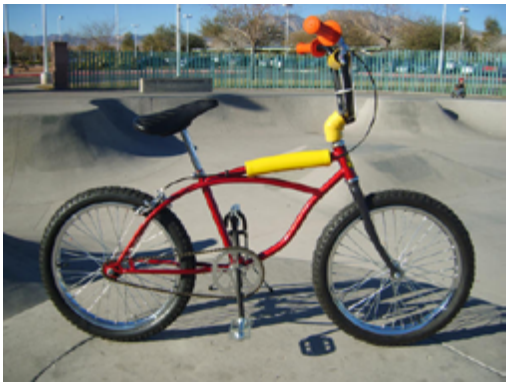

Figure 3. 1969 Huffy All-Pro Dragster III. Image by permission: http://bmxmuseum.com/bikes/huffy/48016.

Looking back, I could say this DIY hack sowed the seeds of the permission I gave myself to modify a store-bought bike into something altogether more personal, while still retaining legitimate utility as transport.

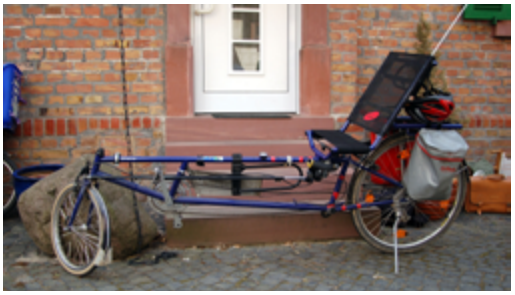

Figure 4. Pichler Langliegerad. Photograph: Eva K, GNU Free Documentation License, Version 1.2.

Figure 5. Windcheetah. Photograph courtesy of Karl Sparenberg, Advanced Velo Design.

During a cycle tour from Melbourne to Sydney in 1988, I encountered a handful of Yankees riding recumbent bikes (Figure 4). I recall them moaning about the gravel roads, and dismissed them and their weird bikes for being both impractical and looking deeply uncool. Much later, an image of Mike Burrows' aluminium Speedy SL (or Windcheetah) from the early 1980s convinced me otherwise in terms of recumbent bike aesthetics. I stored away the desire to use my accumulating metalworking skills to one day build myself something like the Windcheetah recumbent. The rarity of recumbent bikes and lack of accessible information about them prevented me from pursuing this desire further until I discovered the Atomic Zombie website.

Canadian Brad Graham has an internet business selling plans for a variety of unconventional cycles, all pitched at low-skilled DIY home builders using largely recycled bicycles as raw materials. I recognised his plans as a resource for understanding materials and fabrication techniques that would be sufficient for a roadworthy bike build.

Figure 6. Andrew Last, launch of *Recumbent #1*.

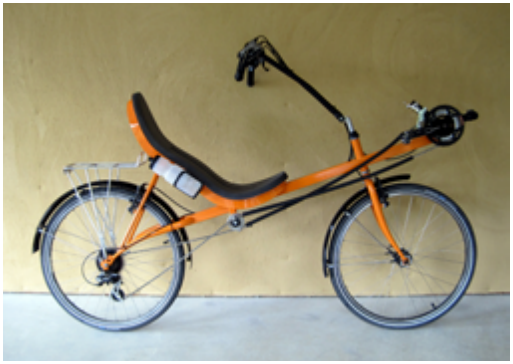

Figure 7. Andrew Last, *Recumbent #1* in regalia.

Figure 8. Andrew Last, *Recumbent #2*.

However, my own metal skills were at a much more sophisticated level than those Atomic Zombie caters for, and I was able to build his High-Roller design quickly and cheaply using a few bikes from the local tip shop and Trademe. The kick experienced from rediscovering how to ride a bike, combined with the satisfaction of riding a bike of my own manufacture, compensated for the machine's performance inefficiencies and rudimentary aesthetics. Despite its inadequacies, I rode this bike for eight months and it entirely replaced my mountain bike as a commuter vehicle.

At the time, my partner Bron and I were commuting together on a store-bought tandem bicycle. Without any say from Bron, I decided that my next project (two months after the making of the first recumbent) was to replace our entirely adequate tandem with a modified Atomic Zombie tandem recumbent design. The new tandem was as satisfying to ride as the single, so we decided to give the store-bought bike to Bron's sister.

This bike provoked squeals of joy from kids who spotted us riding by, and drew the unavoidable smart comments from disbelieving adults ("The one on the back's not pedalling!")

By now, my obsession with refining these bikes was in full swing. My first single recumbent was awkward as a result of the high pedalling position, and I could feel that both bikes were losing power transfer because of insufficiently rigid frames.

The next single bike I made was my own design, compiled from extensive internet research on commercial and DIY recumbents. My aim was to build a better commuter bike. The lower seat and pedal height made it much easier to start and stop, and I used better quality recycled bikes to make the bike lighter and more rigid. These improvements compensated for the less efficient frontal wind-reduction area associated with this style of bike.

I found that my second single recumbent was faster than the first, due to a combination of improved mechanical efficiency (a more rigid and lighter frame) and greater comfort (I found the lower pedalling position less fatiguing).

The green tandem recumbent also suffered mechanical losses due to its flexible frame. The other major disadvantage was that the (conventional) linked pedal system demanded that both riders pedal at the same cadence. I naturally prefer to pedal at a higher cadence than my stoker, Bron.

I redesigned a tandem around an independent front and rear wheel drivetrain and introduced improvements to the rigidity of the frame construction. I also added disc brakes to make stopping more reliable. This bike was again my own design. Because of the independent drive systems and stronger frame, this bike is a great improvement on the first tandem. However, the low pedal height of the rear rider and the relatively vertical seat positions mean that there is no great frontal area improvement compared to a conventional upright tandem. It's slow in a headwind.

Bike number five is as much an acknowledgement of my bike-building habit as it is a further development in pursuit of the ideal commuter bicycle:

This bike concedes some loss of traffic visibility in a desire to gain as much aerodynamic advantage as possible. It successfully achieves practicalities of comfort, load-carrying ability and manufacture from easily accessed materials.

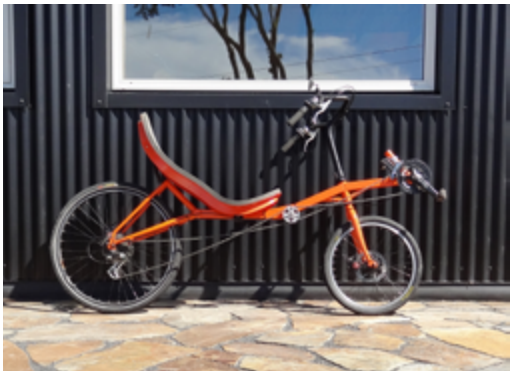

Figure 9. Andrew Last, *Recumbent #3*.

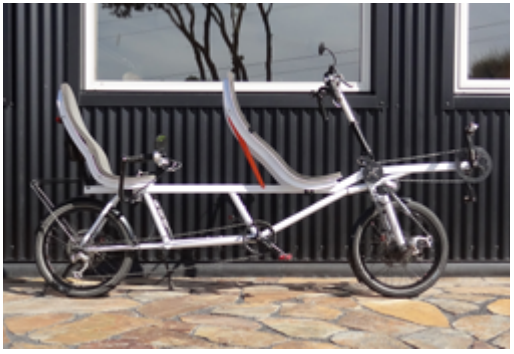

Figure 10. Andrew Last, *Recumbent #4*.

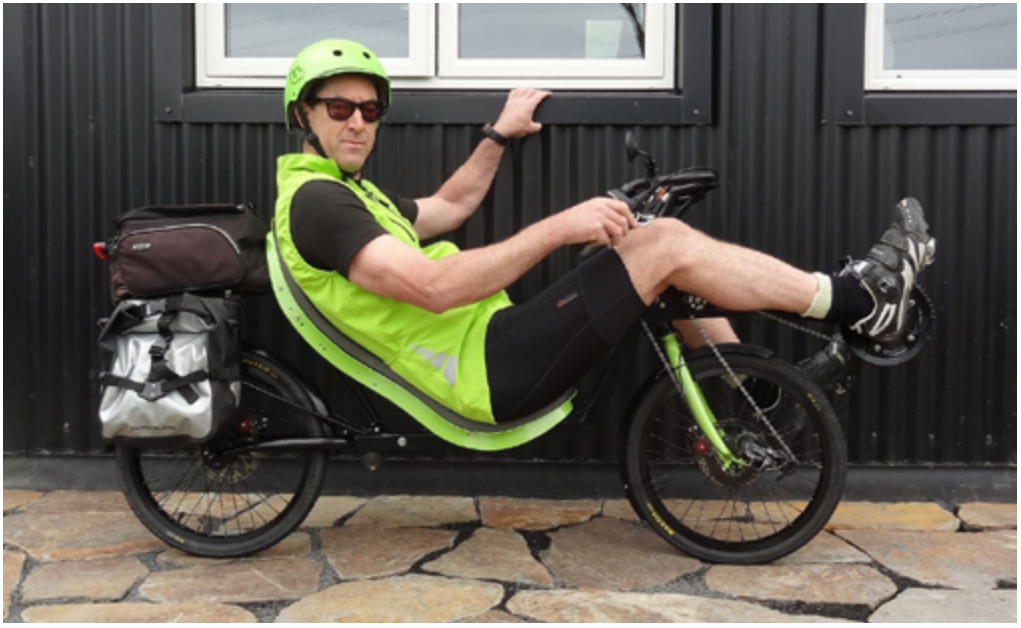

Figure 11. Andrew Last, *Recumbent #5*.

While the seat is quite reclined, forward view is unimpeded; neck position is still neutral and due to less pressure on the backside, combined with rear suspension, it is the most comfortable of all the recumbent bikes I've made. On the flat, I can keep up with road bikes. At 16kg the bike is slower going up hills, but its small frontal profile gives it a huge speed advantage going downhill and cycling into a headwind.

CONVENTIONAL VS RECUMBENT BICYCLES

Figure 12. Aerodynamics of a diamond-frame bicycle compared to recumbent models. Image courtesy of Dana Leiberman, Bent-Up Cycles. This image illustrates progressively faster riding positions on a conventional bike and two comparative recumbent positions.

The reduction in frontal profile is the main claim recumbent bikes make for improving efficiency. Wind resistance is the greatest loss a cyclist has to overcome at speeds of 15kmh,[1] and increases dramatically at speeds greater than 15kmh. On a recumbent cycle, the frontal profile is dictated mainly by the degree of seat recline and height of the pedal axle (bottom bracket). The recumbent rider on the far right in Figure 12 is reclined such that he can just see over his knees, and his feet project neither higher than his head nor lower than the seat.

The other major claimed advantage recumbent bikes have over upright designs is comfort and, by inference, reduced levels of fatigue. In Figure 12, the riding position at the far left is the most comfortable, with the rider having a vertical pelvis and his weight borne by the gluteus maximus. As the rider rotates forward to decrease frontal area, pivoting on the 'sit bones' changes the point of contact on the saddle and increases the weight borne by the arms and neck muscles. The degree of comfort decreases accordingly. By contrast, the recumbent seat distributes the rider's weight more evenly and typically eliminates weight on the arm and neck muscles.

RECUMBENTS AS RACERS

It is interesting to note the absence of recumbent bicycles in cycle racing – they have been effectively banned since 1934 by the Union Cycliste Internationale (UCI), the governing body of cycle racing. The previous year, the Vélo-Velocar, designed by Charles Mochet, had been ridden to a new record of 45.055km over one hour by French rider Francis Faure.[2]

This ban ostensibly ensures that athletes compete on equipment that does not offer any unfair advantage. It has been argued that the UCI ban on recumbent racing bikes has relegated their technological development to the fringes of cycle manufacturing and therefore hindered the development and uptake of more utilitarian recumbent bikes.[3] The UCI maintains this ban in 2015.[4] Despite the resulting inhibition of recumbent cycle technology, organisations such as the International Human Powered Vehicle (IHPV) Association are fostering their development and recognising speed and distance records achieved by these bicycles. Most significant cycling speed and distance records are held by recumbent bicycles, particularly those enclosed within a streamlined fairing shell.

Figure 13. Francis Faure on his Vélo-Velocar, 1933. Reproduced by permission of Alexandre Pépin, www.velorizontal.com.

At 133.78kmh, the world 200m unpaced flying start record is held by Sebastian Bowier pedalling VeloX3, a streamlined recumbent in which the rider relies on a camera for forward vision (Figure 14).[5]

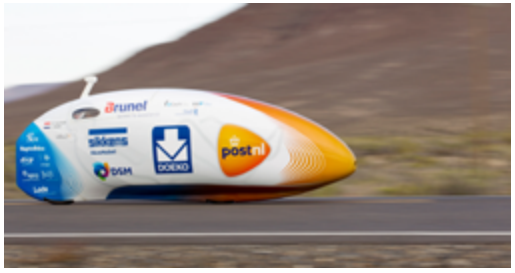

Figure 14. The streamlined recumbent VeloX3. Credit: Bas de Meijer, Creative Commons attribution share alike.

THE VELOMOBILE

The ultimate utilitarian transportation derivative of a streamlined racer is the velomobile.

Vittouris and Richardson observe that velomobiles promise the ultimate in aerodynamic advantage, speed and weather protection.[6]

In a culture where automobility is dominated by the petrol-engine sedan car, velomobiles are at the cutting edge of recumbent/HPV development. In order to broaden their appeal, velomobiles need to be developed for low-speed urban use, vehicle ergonomics, load capacity and visibility. " The concept of the velomobile can play an important role to offset the unsustainable transportation patterns in the post-modern world and its development as a technology of transportation is a unique opportunity that should be seized."[7]

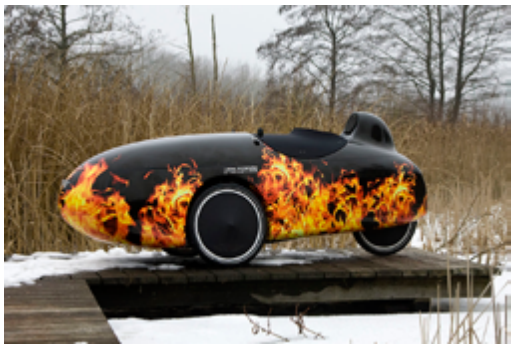

Figure 15. Sinner Mango Velomobile (Velox Incendia). Credit: Emiel Ketelaar, Creative Commons Attribution-Share Alike 3.0.

Vittouris and Richardson discuss the contribution of Do It Yourself (DIY) approaches to velomobile uptake and diversification. They argue that the niche market currently held by velomobiles necessitates a DIY approach to finding solutions to technical and design challenges where the vehicle maker is directly involved in problem-solving and implementation.[8] Subsequent evaluation and analysis generates new problems to solve by means of a cyclic rather than linear methodology. The net result is an iterative series of new prototype revisions. The iterative design process has become the research methodology which has formed the basis of my own recumbent development project.

Vittouris and Richardson discuss the potential of Open Source Information Systems for furthering the development

of velomobiles. These systems are typified by the kind of software development conducted in an information technology environment where authors are not bound by a hierarchy of corporate ownership and may work collaboratively. The capacity for many designers to share information in a Computer Aided Design (CAD) format via the internet, and the increasing accessibility of Computer Numeric Control (CNC) machines such as laser cutters and 3D printers, offer potential to extend the possibilities of DIY manufacture.[10]

THE MAKER MOVEMENT

As a popular culture phenomenon, DIY has seen renewed interest in recent years through its association with the Maker Movement:

> The maker movement, as we know, is the umbrella term for independent inventors, designers and tinkerers. A convergence of computer hackers and traditional artisans, the niche is established enough to have its own magazine, *Make*, as well as hands-on Maker Faires that are catnip for DIYers who used to toil in solitude. Makers tap into an American admiration for self-reliance and combine that with open-source learning, contemporary design and powerful personal technology like 3-D printers. The creations, born in cluttered local workshops and bedroom offices, stir the imaginations of consumers numbed by generic, mass-produced, made-in-China merchandise.[11]

My education and background as an art-school trained jeweller and metalsmith aligns me with the traditional artisans described in the above definition. I am interested in the ways that contemporary DIY or Maker Culture may influence both art and craft education and, in turn, how DIY art and craft practice may be part of a movement toward sustainable development in general.

American jeweller and craft writer Bruce Metcalf enumerates the advantages of craft-based activism:

> Craftivists, like local food advocates, think about shifting production back into the hands of ordinary people. They promote the same ideals of self-empowerment that motivated both Ruskin and Morris. By getting people to make useful objects for themselves, they hope to decrease complicity in modern consumer culture. Handmade objects could last longer, or be used longer, than their mass-marketed equivalents. Handmade things could have a smaller carbon footprint. They could reduce the need for income, and if pursued in the community setting I mentioned before, they could become agents in social bonding and mutual help networks. The point, I think, is that if craft is practiced on a massive scale, the world would be better off for it.[12]

Figure 16. A Critical Mass event in Brussels. Photograph: Ben2, Creative Commons.

AGENT OF PROTEST

The bicycle has a rich history as an agent of political protest. In his book *One Less Car: Bicycling and the Politics of Automobility*,[13] Zach Furness discusses the history of the bicycle as an agent of protest against the motor car:

"In Holland in 1965 an anarchist group called Provo proposed several plans for social change including a White Bicycle Plan: ban automobiles from Amsterdam and launch a free bicycle program."

"Pro-bike/anti-car activities first appeared in North America in 1970 with a Bicycle Ecology Day in Chicago and then a 1972 protest in New York City where bicyclists rode by an auto show chanting 'cars must go!'"

"Critical Mass, the once-a-month, leaderless rides that originated in San Francisco in 1992 and continue through to the present day have been perceived as protest activities. Large groups of cyclists gather at regular intervals and ride *en-masse* through city streets, displacing the automobile. The rides make a highly visible claim that cyclists are not blocking traffic, they are traffic."[14]

CONCLUSION

After five years of almost exclusive recumbent cycling, I am convinced that for me it is a better way to ride. For my commute, a recumbent is faster and more comfortable than a conventional bike. The added satisfaction of riding a self-made bike and the opportunity to dynamically gather design feedback with each ride make the continuation of this project even more compelling. Although recumbent bikes are still on the margins of cycle culture, the global connectedness of the internet allows access to a community of riders, designers, makers, and manufacturers of recumbent bikes. This access has enabled me to produce bikes that are comparable in quality and performance to those that are professionally built. Having ridden in excess of 3,000km in the last year, I am confident that my local community have noticed me riding and accept my unusual bike as a legitimate if slightly eccentric vehicle.

In conclusion, my DIY recumbent bicycle project has successfully drawn together the research, design and making aspects of my practice, together with an understanding of cultural contexts that give a wider meaning to the work.

After studying engineering for a short while, **Andrew Last** received a BA (Fine Arts, Gold and Silversmithing) from the Royal Melbourne Institute of Technology (RMIT) in 1987 and an MFA from RMIT in 1994. Andrew has been teaching jewellery and metalsmithing in Australia and New Zealand since 1989, and is the Studio Coordinator for jewellery and metalsmithing at the Dunedin School of Art. His practice spans the disciplines of jewellery, silversmithing, design, sculpture, luthiery and occasionally architecture.

1 Peter T Cox, "Energy and the Bicycle – Human Powered Vehicles in Perspective," paper prepared for "Energy and Innovation," Seventh International Conference on the History of Transport, Traffic and Mobility (T2M), Lucerne, Switzerland, 5-8 November, 2009, http://www.academia.edu/267207/Energy_and_the_Bicycle_-_Human_Powered_Vehicles_in_Perspective, p. 7.

2 Ibid., 18.

3 Ibid.

4 *UCI Cycling Regulations. Part 1 – General Organisation of Cycling as a Sport*, 13 March 2015, http://www.uci.ch/mm/Document/News/Rulesandregulation/16/80/73/1-GEN-20150313-E_English.pdf.

5 *World Human Powered Speed Challenge 2015*, http://www.recumbents.com/wisil/whpsc2015/speedchallenge.htm.

6 Alexander Vittouris and Mark Richardson, "Designing for Velomobile Diversity: Alternative Opportunities for Sustainable Personal Mobility," *7th International Velomobile Seminar Programme*, 7-8 September 2012 (Dronton, The Netherlands: NVHPV (Dutch Society for Human Powered Vehicles)), 1-36. See also http://www.velomobileseminar.com/downloads/Vittouris_Design-diversity.pdf.

7 Frederik Van De Walle, "The Velomobile as a Vehicle for more Sustainable Transportation: Reshaping the Social Construction Of Cycling Technology," MSc thesis, Royal Institute of Technology, Department for infrastructure, Stockholm, Sweden, 2004, http://users.telenet.be/fietser/fotos/VM4SD-FVDWsm.pdf.

8 Vittouris and Richardson, "Designing for Velomobile Diversity," 9.

9 Cal Swann, "Action Research and the Practice of Design," *Design Issues*, 18:1 (Winter, 2002), 49-61.

10 Vittouris and Richardson, "Designing for Velomobile Diversity," 10-16.

11 "Which Big Brands are Courting the Maker Movement, and Why: From Levi's to Home Depot," 17 March 2014, http://www.adweek.com/news/advertising-branding/which-big-brands-are-courting-maker-movement-and-why-156315.

12 Bruce Metcalf, *DIY, Websites and Energy: The New Alternative Crafts*, 2008, http://www.brucemetcalf.com/pages/essays/diy_websites_energy.html.

13 Zach Furness, *One Less Car: Bicycling and the Politics of Automobility* (Philadelphia, Temple University Press, 2010).

14 Ibid.