



connected sustainable cities

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Printed in the United States of America.
First printing 2008.

ISBN-13: 978-0-9821144-0-7
ISBN-10: 0-9821144-0-0

Library of Congress Cataloging-in-Publication Data



MIT Mobile Experience Lab Publishing

www.connectedurbandevelopment.org
www.mobile.mit.edu

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Book design by Pamela Botacchi, Pearl Graphics

five/taking personal responsibility

The overwhelming majority of us in the developed world have individual carbon and water footprints well in excess of what the planet can sustain. What can be done, especially since what may be the biggest variable in sustainability is human behavior?

Scenario: knowing your carbon and water footprint

It is difficult to manage our individual carbon and water footprints if we don't know what they are and the effects of our actions on them. How can we take advantage of connectivity to supply the information that will enable us to make better resource-use choices?

It is a simple fact of human existence that we cannot solve our problems without knowing some details about their composition. Those details make it possible for us to put problems in context and begin to see how we might solve them – even if it requires altering our behavior to make different choices. Today, we lack sophisticated information about our individual carbon and water footprints and thus are missing a key part of what we need to solve a very big problem.

Electronically collect and distribute up-to-date, accurate information that enables and promotes sustainable personal choices.

Joe and Tom, both in their late twenties and both single, have been rivals since the beginning of high school. They battled for the varsity quarterback position on the football team. They competed for the affections of the same girl. They tried to outdo each other by having the coolest car.

After high school and college, both men returned to their suburban hometown and ended up working for the same company, where the rivalry continues over everything. However, no one ever expected these two to compete for who could have the most environmentally friendly carbon footprint. But since Joan, the high school girl they vied for (who is still single), moved back to town as the environmental coordinator for the local government, Joe and Tom have become the veritable poster boys for sustainability. Every day, they compete to impress Joan by sticking to their carbon budgets – which they do with clear, reliable information that helps them make the right choices.

These days, Joe and Tom both take public transit to their company office. Only on the weekends might they be found driving around town. A decade ago, a Saturday night for these two might have meant a drag race in souped-up, gas-guzzling monster cars out at the edge of town, but now both men drive highly fuel-efficient cars – and drive them as little as possible. This particular Saturday, Joe is feeling particularly good about driving because his car is sending data to his personal computer showing that he has probably bested Tom in fuel-efficiency for the month. He'll be sure to let Joan know the results when they have dinner next Tuesday.

Tom has spent the last week on one of those so-called “home vacations” – the kind where you have time off from work but don't go away. He's gotten a lot done around the house, gone to a ballgame, and taken in some of the area's nightspots (even getting Joan to join him once). As much as possible, he's taken the bus or train during the week, which has meant some walking as well. His personal travel assistant helped him track the time he spends traveling during the week, but more importantly it was key to monitoring his carbon footprint and energy budget during those travels. Each day he would log on to the website and specify his travel plans, which would generate a carbon, time, and energy budget for each trip. These would then be synchronized with his mobile device, and sensors throughout the area would continually monitor and update how he was doing with his budget. If he went over budget one day, he would adjust his travel plans for the next, to keep within his budget and show Joan what a good conservationist he is.

The week at home has also given Tom a chance to try out a new monitoring system he's installed that lets him know how much electricity he's using. Tom's house is pretty efficient, but the new system will let him see, in real time, just what his usage looks like and whether there are any patterns that suggest he's losing efficiency to particular appliances. He's hoping that he can tell Joan he doesn't need to replace his refrigerator because it's working so well.

Monitor, monitor, monitor ... that's a lot of what both men do. They realize that the key to winning Joan's heart is to show her they're making the right decisions, and that means they need a lot of clear information that is meaningful – and actionable.

At Fred's house, the latest monitoring he's undertaken involves his water footprint. He has installed a device that tracks his water use in much the same way that his in-home system monitors electricity, and he's using a new hand-held device that allows him to monitor his water use when away from home. Soon he'll be able to boast to Joan that he's taken steps to conserve local water – something he's sure Tom has yet to catch up to.

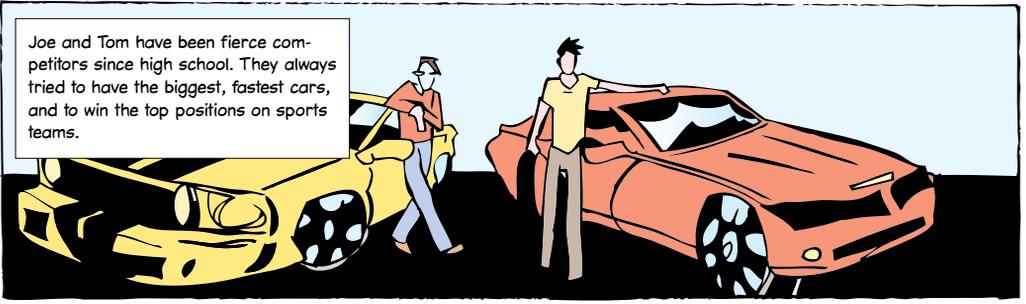
The competition rages. Joe and Tom will do anything to win Joan the environmentalist's affections. We're not sure Joan benefits, but the earth certainly does.

Enabling technologies

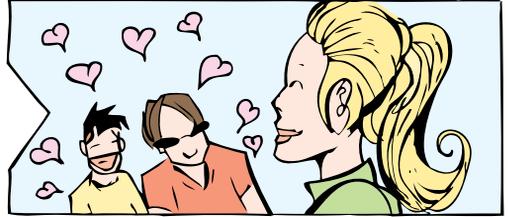
In-vehicle environmental performance data

One key to the ongoing competition between Joe and Tom is that they are continually aware of the contribution of their automobiles – when they do drive them – to their individual carbon footprints. For car owners in Japan, Nissan has introduced a function of the telematic in-car navigation system that, in addition to providing real-time traffic information and directions to drivers, also can show drivers their personal fuel consumption trends while they are on the road. The Nissan Eco-Drive software also provides a ranking of each driver's fuel efficiency relative to all owners of the same automobile model, and offers tips for reducing consumption – all of which help make sustainable behavior choices

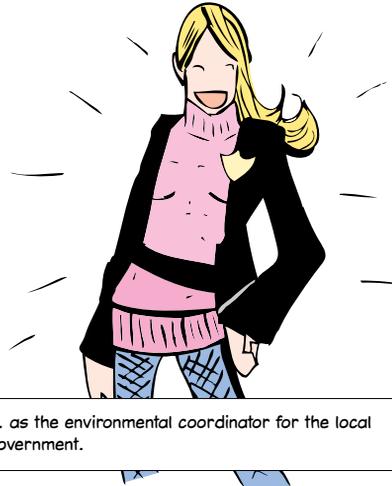
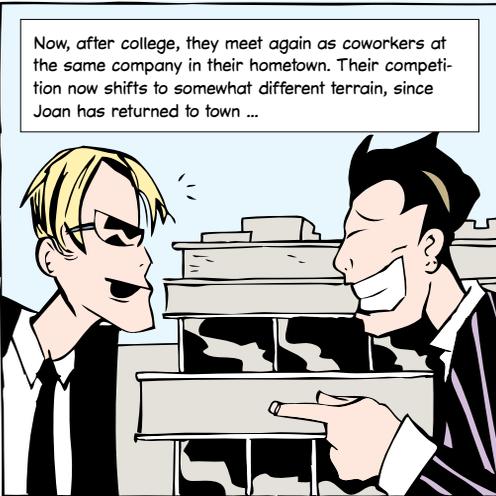
Joe and Tom have been fierce competitors since high school. They always tried to have the biggest, fastest cars, and to win the top positions on sports teams.



They even competed for the attention of the same girl, their beautiful classmate Joan.

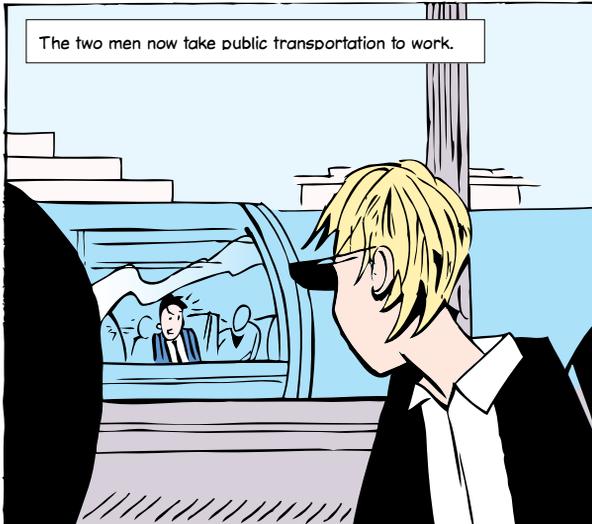


Now, after college, they meet again as coworkers at the same company in their hometown. Their competition now shifts to somewhat different terrain, since Joan has returned to town ...

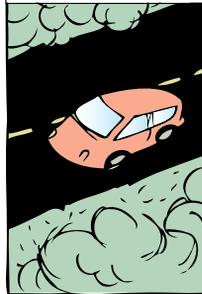


... as the environmental coordinator for the local government.

The two men now take public transportation to work.



They've traded in the huge, gas-guzzling cars they drove when they were younger for smaller, fuel-efficient automobiles that they drive mostly on weekends outside the city.



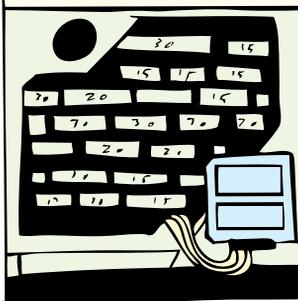
They have both begun to monitor their activities to decrease their carbon footprints and energy budgets both at home, when on the move, and at work.



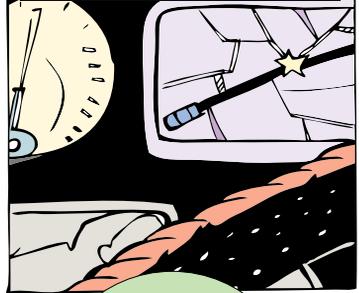
Tom installed a device that helps him monitor his water footprint by tracking his water use ...



... and an electricity monitor that works in real time, helping him make decisions that reduce wasteful use of appliances and lights.



For his part, Bill has been using his hybrid car's monitoring system to achieve better fuel-efficiency than Tom. He also uses it to monitor in real time how far he can drive while conforming to specific energy, fuel, or time budgets.



WHILE OFF WORK...

Every morning, Tom launches an online application to specify time, carbon, and energy budgets for the day. This lets him see his energy spending in real time and helps him find the most optimal routes.



TOM HAS BEEN USING HIS **PERSONAL TRAVEL ASSISTANT** TO TRACK HIS TRAVEL AND HIS CARBON FOOTPRINT IN REAL TIME

Bill and Tom are obsessive about the results of their choices; they have all the information available thanks to the energy-monitoring applications of their devices.



Joan is amused by her friends' new style of "eco-flirting," but she knows quite well that the biggest beneficiary of their healthy competition is **PLANET EARTH.**



easy and desirable. Knowledge of real-time fuel economy demonstrably encourages drivers to change their driving habits.

In Toyota's Prius hybrid, a touch-screen display "Energy Monitor" shows energy flow to and from the engine, battery, and regenerative braking system. The monitor not only displays the customary battery charge level, engine status, and outside temperature, but provides a dynamic bar graph of fuel efficiency for the trip, as well as current and accumulated miles-per-gallon data.

Individual carbon and water footprint tracking

Joe and Tom make responsible decisions each day based on information they receive in real time about their individual carbon footprints. This information comes from a variety of sources. Today, the Vulcan Project is working on a virtual carbon footprint map of the United States that will be able to identify sites of significant emissions at a much higher resolution than previously possible, including at individual factories and power plants as well as in neighborhoods and on roadways. When fully operational, the Vulcan Project mapping capabilities will provide real-time data updated hourly. The project is a North American Carbon Program initiative funded by NASA and the U.S. Department of Energy and involves researchers from several universities. The Vulcan Project makes these data available to anyone with an Internet connection, empowering individual citizens and interest groups to develop local sustainability programs based on these data.

Joe and Tom also keep track of their personal water footprints using online tools. Water footprint calculators allow individuals to figure out the water required to produce the goods and services they consume.

Home electricity monitoring

Both Tom and Joe are very conscious of their home electricity use, which they continually monitor with built-in devices in their homes. Kill A Watt is a monitoring tool for home use that helps users assess the efficiency of appliances. The display shows electricity consumption by kilowatt hours, and monitors voltage and line frequency. Electrical expenses can be calculated by any time measure, from day to year. Wattson is a sys-

tem for the home that uses sensors that attach to cables or fuse boxes in the home, sending information to a transmitter. Output information includes the amount of electricity coming into the home and the cost of electricity in use at any moment.

Data from devices such as Kill A Watt and Wattson can be aggregated by Pachube, a web service wherein people share “real-time environmental data from objects, devices and spaces around the world.” The result is a global picture of energy use.

Personal travel assistant

During his week off from work, Tom travels around the metropolitan area, always mindful of his carbon footprint and energy budget. He uses a personal travel assistant to keep track. The Mobility Opportunity Map concept developed at MIT is a mobile object available online, on a mobile phone, or even on a car dashboard, that makes it possible to track carbon, time, and energy budgets while traveling. A user can customize and adjust the budget. Carbon use is calculated based on the number of trips, distance, time, and other variables, according to a personalized schedule, which provides the information a user needs to make activity adjustments throughout the day to promote sustainability.

Lessons

In the end, there are just three fundamental ways to make cities more sustainable. We can increase the supply of the scarce resources cities need; we can, by introducing more efficient processes and other measures, reduce the demand of cities on those resources; and, through changing the behavior of individuals and groups who consume resources, we can try to bring supply and demand into better balance.

Regulation backed by enforcement is one way to change behavior. Governments can, for example, require that new homes have better insulation in order to reduce heating bills, or solar panels in order to reduce their external electricity requirements. An alternative is to provide citizens with data and analysis tools that allow them to keep track of their consumption of energy, water, and so on, and keep track of their

production of greenhouse gases and other harmful products, and then to provide economic and other incentives to minimize their consumption and waste product footprints.

This latter strategy is attractive, and promises to be very effective in many contexts. However, it depends upon capabilities to track behavior electronically in real time, analyze and visualize the resulting data, and – via mobile devices and other means – deliver the results of analyses and visualizations directly into contexts where citizens are actually making decisions. Connectivity, together with new software tools, is now providing these capabilities.

Connected sustainable cities, which will evolve over the next decade, employ ubiquitous, networked intelligence to ensure the efficient and responsible use of the scarce resources – particularly energy and water – that are required for a city's operation, together with the effective management of waste products that a city produces, such as carbon emissions to the atmosphere.

Through a series of prospective scenarios, *Connected Sustainable Cities* illustrates some of the ways in which inhabitants may use and manage their living spaces, move around the city, work, shop, pursue their educational, cultural, and recreational interests, and make well informed, responsible personal choices. These scenarios are accompanied by brief sketches of the existing and emerging technologies, products, and systems that will support new, intelligently sustainable urban living patterns. In addition, there are short discussions of some of the theoretical, policy, and design issues that these scenarios raise.

Connected Sustainable Cities is a starting point for the investigations and debates that will be necessary as citizens, technologists, designers, policy experts, and political and business leaders begin to shape the new urban areas we urgently need to create in the near future.



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Printed in the USA with soy based inks
on FSC certified paper

ISBN-13: 978-0-9821144-0-7

ISBN-10: 0-9821144-0-0



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