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# HCI and Sustainability: The Role of Macrostructures

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**Abstract**

Sustained behavior changes are required to reduce the impact of human society on the environment. Much research on how HCI may help do so focuses on changing behavior by providing information directed at an individual or a microstructure (e.g., household). We propose societal macrostructures (e.g., municipalities) and their interaction with microstructures as a focus for HCI aimed at designing behavior change. We present two ongoing case studies involving municipalities in Denmark and discuss how and why macrostructures may be used in the design of HCI for behavior based environmental sustainability.

**Keywords**

Sustainability; Society; Design Space

**ACM Classification Keywords**

H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces - Haptic I/O, Input Devices and strategies, Interaction styles.

**Introduction**

To sustain the environment in the long term changes must occur in the way resources are consumed. Some changes will happen through the introduction of renewable energy sources, based on wind, water, and

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CHI'12, May 5–10, 2012, Austin, Texas, USA.  
ACM 978-1-4503-1016-1/12/05.



**Figure 1:** Example of interacting macro- and microstructures

sun. Other changes will happen through new behaviors in energy consumption, use of transportation, waste management, and so forth. Many have presented arguments as to how HCI can help achieve environmental sustainability [3, 5, 8, 12].

Most research and innovation in HCI focus on the consumption habits and awareness levels of individuals, households, and other “small” societal structures. We call these *microstructures*. Much of the work focusing on microstructures aims at creating awareness and motivation through persuasive computing [17], eco-visualizations [4, 9, 11, 13], or computer games [10, 14]. Information distribution and visualization are used with the intention of increasing awareness and thereby affecting behavioral patterns of individuals. This focus on microstructures represents a bottom up approach for creating large-scale changes in behavior that affect the environment.

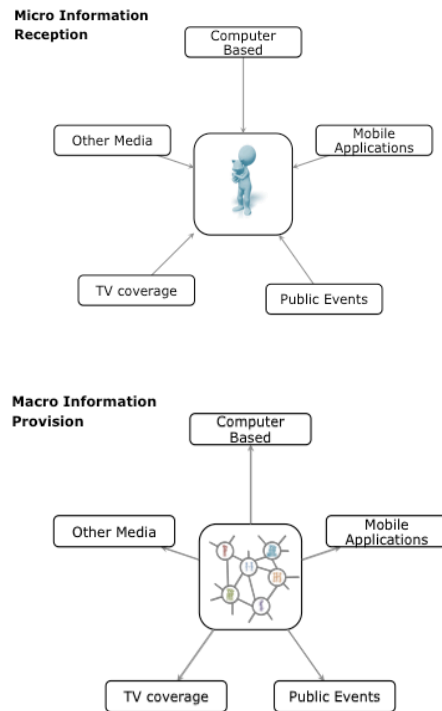
We argue that designing top down solutions that tap into existing societal *macrostructures* could also be beneficial (Figure 1). We first present three scenarios that illustrate how macrostructures help facilitate behavior change. We next discuss two large-scale, ongoing case studies with Danish municipalities.

### Why Macrostructures Matter

Macrostructures are public and private networks that frame everyday life, including municipalities, private waste management, and transportation companies. Macrostructures provide both the infrastructure and the facilities that can support environmentally sustainable behavior. In this regard macrostructures could benefit from HCI through the use of visualization and simulation [7], through the design of green nudges [15,

16], and by providing tools that support, engage, and focus on citizen action and innovation [1, 2, 6]. Visualization and simulation can provide an overview of resource consumption of government owned buildings, public transportation, waste management, and so forth. Project Dasher [7] is an example of a prototypical tool that seeks to create a real time simulation of the energy consumption in a building. This type of large-scale data visualization and simulation could be extended and provide municipalities with tools that inform both daily management and city planning. Nudging [16] is about making the desired citizen behavior the most visible and easiest accessible. As a green example take Rutgers University’s decision to make double sided printing the default option. This saved approximately 7.000.000 sheets of paper in one semester (<http://www.inudgeyou.com/green-nudges-saving-trees-by-default/>). Finally, social networks, mobile application and the internet can be used by macrostructures to inform, engage, and nudge citizens. One of the municipal projects mentioned later has this focus.

Let us give a concrete scenario of why macrostructures matter: Ellen lives in Greenbough. The mayor of Greenbough wants the inhabitants of the city to lower their CO<sub>2</sub> emission and has issued campaigns targeting cycling as an alternative to motorized transportation. Ellen loves bicycling, but her work is 40 km away and she finds this too far to bicycle back and forth everyday. The next best thing for Ellen would be to combine bicycling and public transportation to get to work. However, the public transport network in Greenbough has limited access for bicycles and this at extra cost. So she abandons using the bicycle and the public transportation network, and chooses to use her



**Figure 2:** Macro-information provision and micro-information reception

car. This is an example of knowledge and good intentions being overruled by lack of opportunity that could have been provided by the macrostructure. Understanding the individual as part of a collective and addressing the issue of sustainability through macrostructures could potentially provide a greater impact in changing climate behavior on a large scale. Municipalities are an important macrostructure because they control high impact environmental establishments such as power, water and heating supply, waste management, and a host of other public institutions that affect the climate differently depending on how they are managed. But they can also facilitate behavior for actors in microstructures. Incidentally, the company in charge of public transportation in Greenbough eventually decided to invest in public transport units designed for bicycle transportation and allowed free use by its passengers.

### Macrostructures as Facilitators

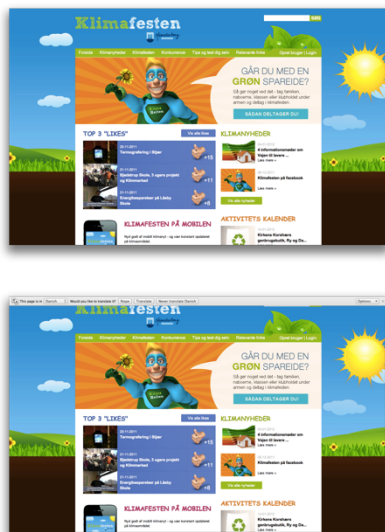
Intention, information, and action are all present in the cross field between micro- and macrostructures. The initial macro-intention is set by the cultural and political climate in a society at a given time. The macrostructure provides general information on this initial intention. The macrostructure has the opportunity to facilitate the required actions. When actions are taken, the macrostructure becomes a receiver of information about the consequences and implications of actions. These in turn inform the overall general intention of the microstructure level. An individual or household has a set of goals. They receive information from a macrostructure through various channels. This information is used to define or inspire specific targets. The realization of these targets depends on opportunity for action. After action is taken the microstructure

becomes a source of information. The above can be viewed as a simplistic model of how macro- and microstructures may interact to produce behavior change.

To exemplify this process consider the following story. The politicians of Greenbough want to lower their greenhouse emissions (initial *intention* at the macro level). They campaign to this effect through websites, press, events, mobile applications, and so forth (*information* provided by the macrostructure, Figure 2). One of their defined targets is to increase the amount of waste that is to be recycled. In order to achieve this they provide sorting bins for every household, a state of the art recycling center, several mobile applications, websites, and educational events to inform and educate citizens (facilitation of *action* at the macro level). As people start acting upon the opportunities, the city receives various types of information regarding the effect of the facilities provided (*information* flowing to and from the macro level). This information then guides Greenbough's future strategy.

### How Macrostructures Could Facilitate

Ellen wants to play a positive role in the fight against green house emissions (*intention* at the micro level). She has seen posts in the online local news about the importance of proper recycling (receiving *information* from the macro level, Figure 3). She decides that she wants to start recycling more (*action* at the micro level). What happens next depends on macro facilitation. Without it, citizens are required to make an extra effort in acquiring knowledge and taking action. In the context of an already busy life, it is likely that sustainable action will not be a priority.



**Figure 3:** Images from the Climate Party website

A way of facilitating Ellen's recycling behavior would be directly through the three bins provided in her driveway. Upon looking she finds a little QR code: Scanning it takes her to the municipality's website for recycling. There she is provided with all the information she needs and downloads the free recycling app that allows her to take a picture of a piece of garbage and receive information on how and where to recycle it (micro level opportunity for *action*). Part of Ellen's recycling behavior is automatically tracked providing the municipality of Greenbough with information regarding her recycling behavior (micro level providing *information*).

This story makes the point that opportunity affords action. With respect to HCI, each part of the sequence on both a macro and micro level holds room for improvement.

### **CIDEA – Citizen Driven Environmental Action**

We explore the role of macrostructures in creating sustainable behavior in the CIDEA project, Citizen Driven Environmental Action (see <http://blog.cidea.dk/>). This project involves both academic and municipal partners in Denmark. The project seeks to achieve two goals. The first is to determine which cognitive and behavioral means are required to engage, motivate, and activate citizens in regard to environmental sustainability. The other is to create solutions based on organizationally embedded HCI, that can be used by local authorities to create opportunity and incentive for citizens to take action in regard to the environment; especially by changing energy consumption, waste management, and transportation habits. There are six municipalities involved in the project, including the municipality for

greater Copenhagen. On the academic side there are partners from computer science, anthropology, and political science. The subsequent examples come from two municipalities that are part of the CIDEA project. The first is the somewhat rural municipality of Skanderborg and the other is the capital municipality of Copenhagen.

#### *Skanderborg: The Climate Party*

This project is an example of a macrostructure trying to support and highlight environmental innovation by presenting citizens with information about opportunity for action and encouraging them to provide information about completed actions back to the macrostructure. Several iterations of this project will be run with the intention of creating an action/information feedback loop.

Skanderborg has 57.717 inhabitants and covers 462,5 Km<sup>2</sup>. The municipality has the goal of becoming CO2 neutral in 2020 in regard to heating and electricity. This goal is to be accomplished by switching to sustainable energy sources. However, Skanderborg has also planned activities to encourage sustainable behavior from its citizens. One such initiative is the Climate Party (*Klimafesten*, Figure 3), a competition running for six months in which citizens are asked to invent and conduct climate related activities and subsequently contribute information about these activities to a website. There are three elements to this project. The first is a website, where citizens can find inspiration and upload material on their activities. The second is a mobile application that provides information related to sustainable behavior. The third is a series of events designed to spread awareness about the project and generate inspiration among citizens.

The overall goal of the project is to change the municipality's influence on environmentally sustainable behavior from being information oriented to being action oriented. The idea is that existing and future citizen activities related to sustainable climate behavior are communicated and made available to others as a knowledgebase and as inspiration. In order to make the citizen's activities visible, it has been important to communicate information regarding both the project 'Climate Party' and potential opportunities for action. This is done through the website, a mobile application, public events, and press coverage.

The research that will be conducted in Skanderborg will focus on continually evaluating the different activities within the 'Climate Party' project so as to assess which activities, propagation, and types of information that result in the most sustained behavior changes.

#### *Copenhagen: Citizen-driven innovation*

This project is an example of a macrostructure that creates facilities that are both inspired by and meant to inspire citizen activities. The municipality of Copenhagen has the goal of becoming the world's first CO<sub>2</sub>-neutral capital by the year 2025. A milestone in achieving this goal is to reduce CO<sub>2</sub> emissions with 20% by 2015. Copenhagen has 539,542 inhabitants and covers 89,78 km<sup>2</sup>, making it the densest populated area in Denmark. In order to achieve the above, the municipality has planned more than 40 actions in seven fields: energy supply, transportation, construction and renovation, city planning, citizen behavior, weather proofing the city, and several cross-disciplinary initiatives. These actions are part of the Agenda 21 Initiative that seeks to address environmental issues by drawing on suggestions made by citizens. Citizens have

been asked to contribute suggestions based on five overall themes: sustainable urban development, consumption and resources, environment and health, environmental anchoring among citizens and companies, and finally Copenhagen as a frontrunner municipality. Employing almost 50,000 people, it is the single largest workplace in the city, making its own environmental impact of great significance. As a macrostructure, Copenhagen is attempting to facilitate behavior change both within itself and for its citizens. It is also drawing on information provided by its citizens in order to facilitate action.

#### **Conclusion**

Behavior changes are required if we are to create environmentally sustainable societies. While information visualization and distribution are important elements, a larger perspective is needed. We suggest exploring how HCI can be embedded into macrostructures as an important research focus. Strengthening the link between public and private transportation and making recycling more accessible are just two of the potential areas of interest.

Overall there are two main objectives of this research. The first is to explore where the intersections between macro- and microstructures. The second is to facilitate environmental action as well as environmental reflection and awareness. This will be done by designing HCI that creates intention, supports flow of information, and facilitates action.

#### **Acknowledgements**

We thank the participants in the CIDEA project, in particular the municipalities of Skanderborg and Copenhagen.

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