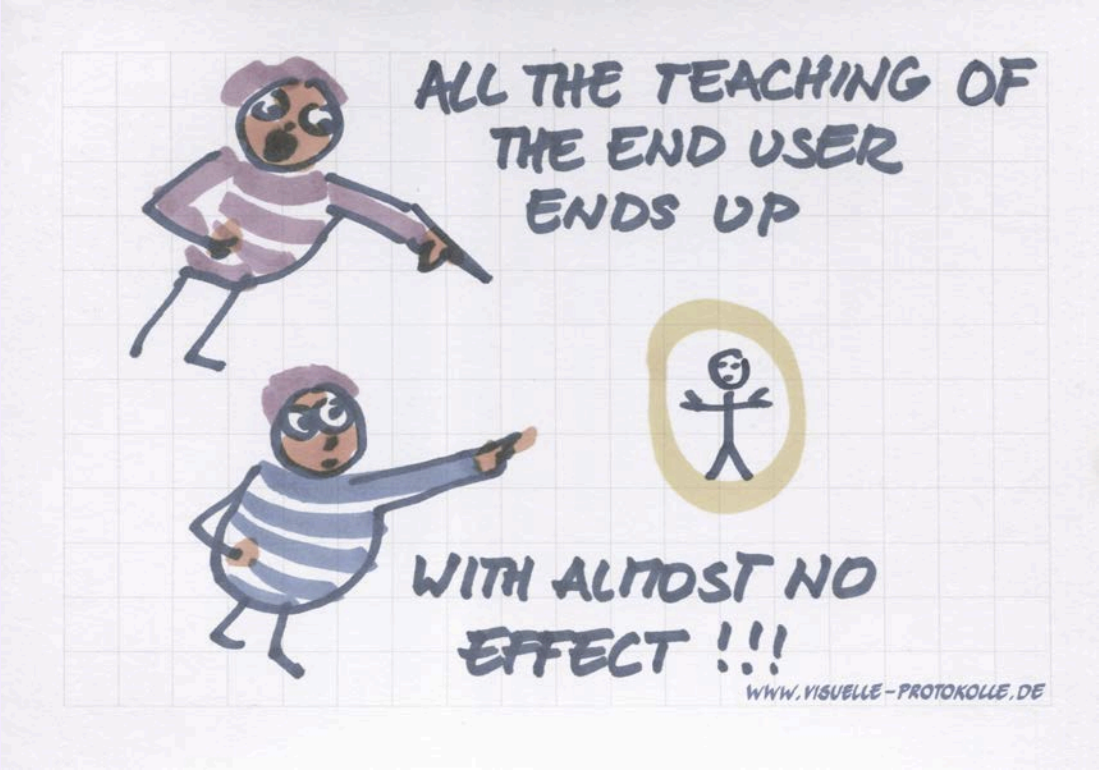
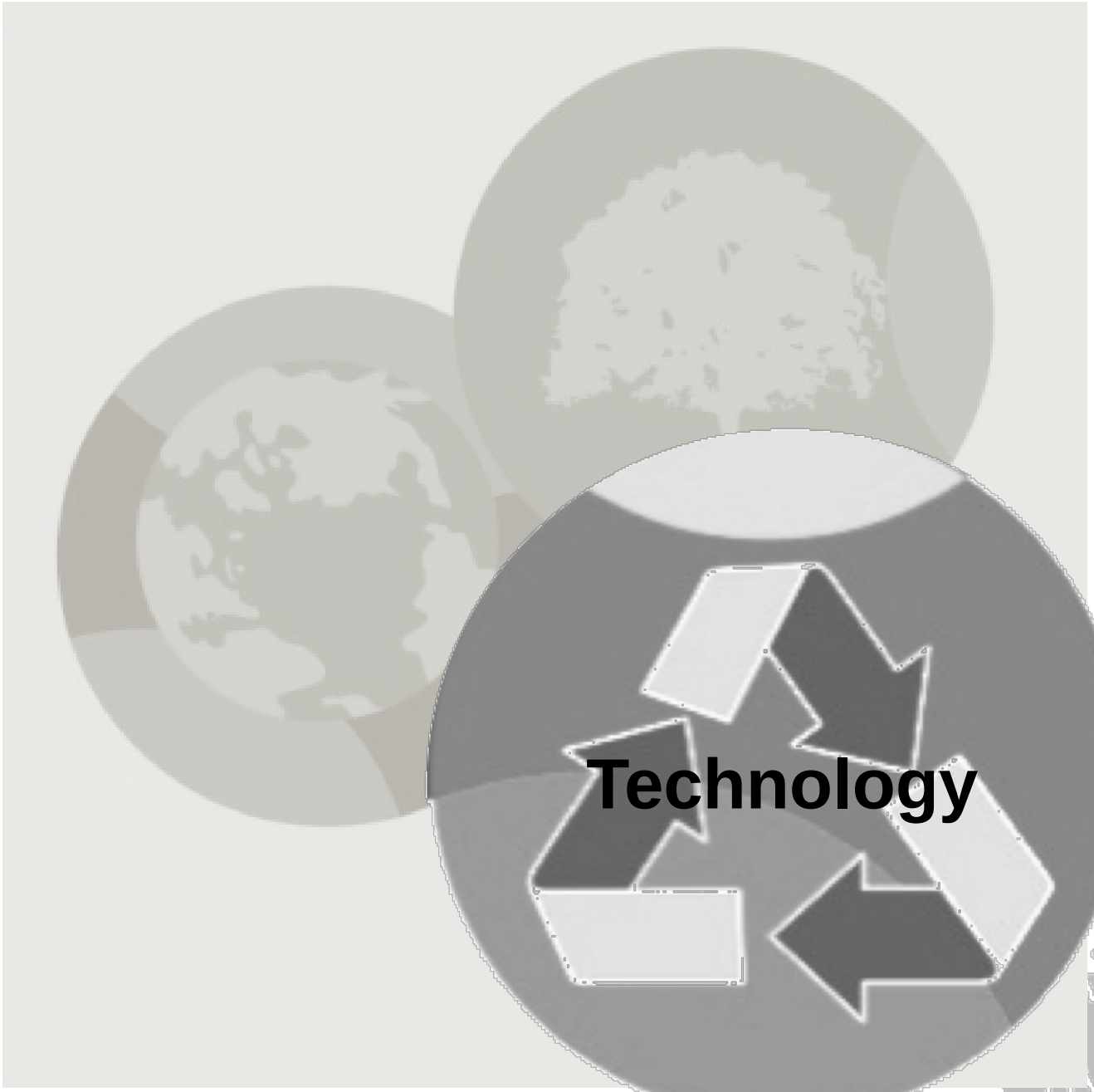
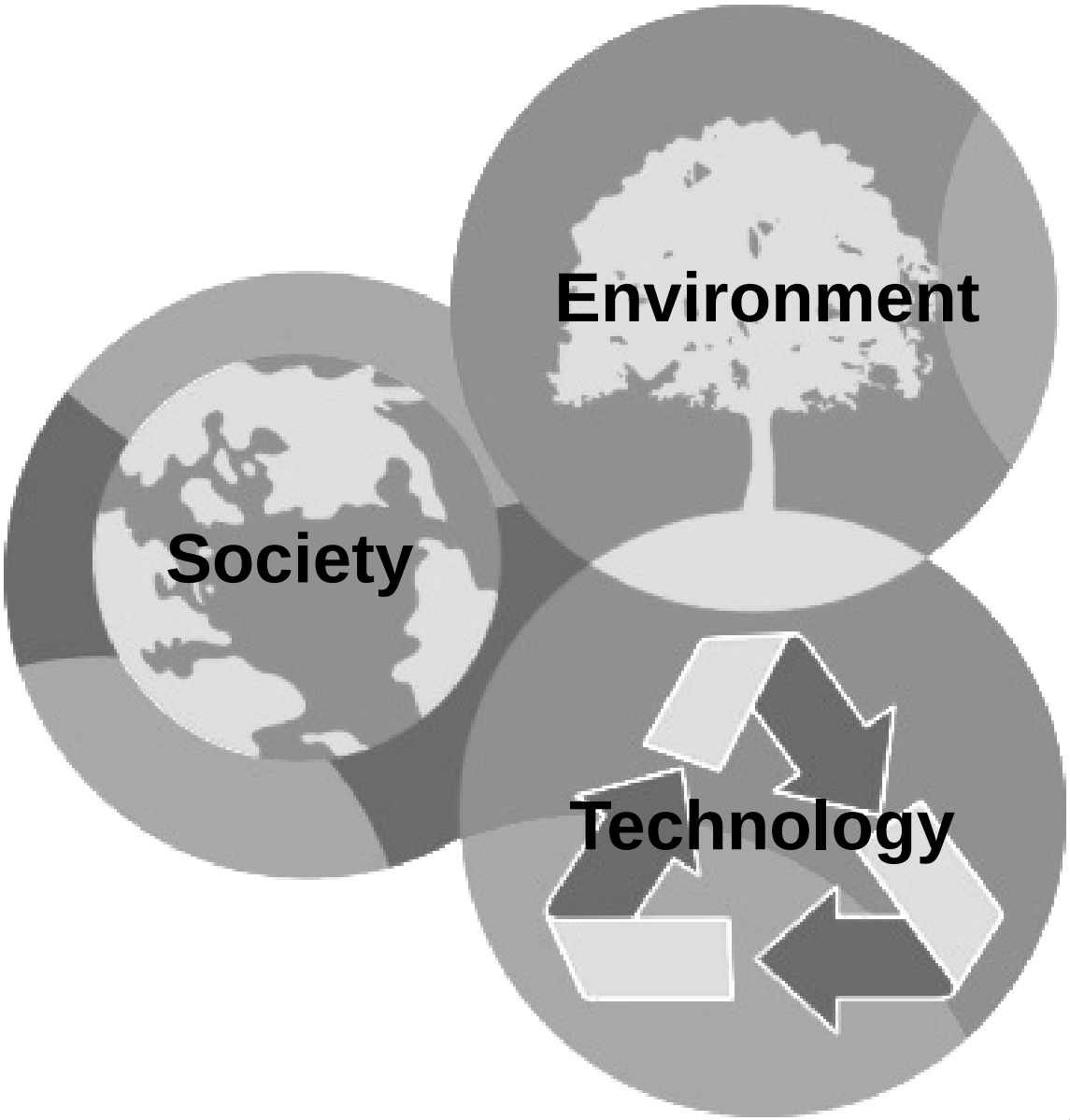


Moving Beyond Feedback

Jennifer Mankoff
(jmankoff@cs.cmu.edu)

Carnegie Mellon


Technology



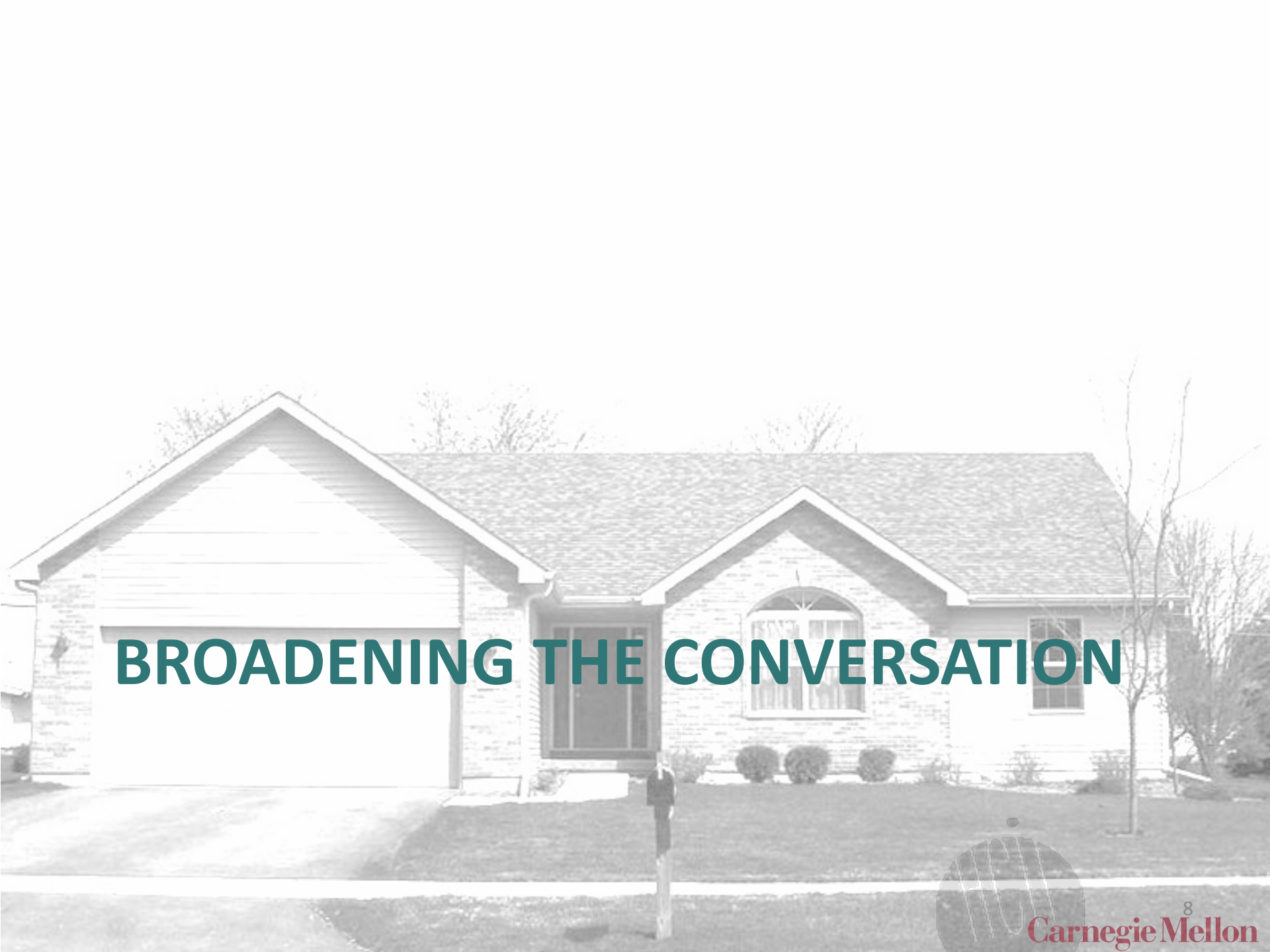
Carnegie Mellon

ICT4S Proceedings Word Cloud

INTERNATIONAL
VARIOUS
IMPLEMENTATION
STANDARD
RECYCLING
MANAGEMENT
LIMITED
PRESENTED
COMMUNITY
ECONOMIC
PRACTICES
DESIGN
FOLLOWING
REFERENCE
CURRENT
DEVICES
LEVEL
NEED
DEVELOPMENT
INDUSTRY
NUMBER
TIME
EMISSIONS
MODEL
SOCIAL
LIFE
SUSTAINABLE
SOCIETY
SERVER
GENERAL
REDUCE
MARKET
ANALYSIS
INCLUDED
IMPACT
GREEN
ENERGY
CREATE
GROUP
HTTP
ELECTRONIC
NEW
DATA
ENVIRONMENT
BUSINESS
RESEARCH
USE
WATER
USERS
MAKE
SECTOR
MEASUREMENT
IMPORTANT
SOLUTIONS
MOBILE
RESULTS
TECHNOLOGY
DIFFERENT
OPERATION
INCREASE
APPROACH
PRODUCTION
RELATED
POTENTIAL
ELECTRICITY
HOME
CONSUMPTION
EFFICIENCY
ICT
CHANGE
STUDY
ACCESS
EFFECTS
POSSIBLE
CLIMATE
CASE
CONSUMERS
SERVICES
ORGANIZATIONS
SCENARIO
POWER
SOFTWARE
PROCESS
PROVIDE
BUILDING
REQUIRED
WASTE
BASED
NETWORK
SYSTEMS
COMPUTING
METERS
FIGURE
ASSESSMENT
PAPER
EXAMPLE
WORK
PEOPLE
PARTICIPANTS
COUNTRIES
APPLICATION
PROJECT
SUPPLY
HOUSEHOLDS

VARIOUS
IMPLEMENTATION
STANDARD
RECYCLING
MANAGEMENT
LIMITED
PRESENTED
COMMUNITY
ECONOMIC
PRACTICES
DESIGN
FOLLOWING
REFERENCE
CURRENT
DEVICES
LEVEL
DEVELOPMENT
INDUSTRY
NUMBER
TIME
NEED
SOCIAL
EMISSIONS
MODEL
SUSTAINABLE
SOCIETY
LIFE
SERVER
GENERAL
SMART
REDUCE
INCLUDED
INTERNATIONAL
ACTIVITIES
AVAILABLE
CITY
ENERGY
CREATE
GROUP
HTTP
IMPACT
MATERIAL
GREEN
ENVIRONMENT
BUSINESS
RESEARCH
USE
USERS
ELECTRONIC
NEW
DATA
MAKE
SOLUTIONS
MOBILE
RESULTS
SECTOR
MEASUREMENT
IMPORTANT
DIFFERENT
OPERATION
INCREASE
APPROACH
TECHNOLOGY
ASPECTS
INITIATIVES
RELATED
POTENTIAL
ELECTRICITY
HOME
PRODUCTION
CONSUMPTION
CARBON
REPORT
EFFICIENCY
ICT
CHANGE
STUDY
ACCESS
EFFECTS
POSSIBLE
INSTITUTE
CLIMATE
SPECIFIC
SERVICES
ORGANIZATIONS
SCENARIO
POWER
CASE
CONSUMERS
SOFTWARE
PROCESS
PROVIDE
BUILDING
REQUIRED
AWARENESS
CYCLE
SYSTEMS
COMPUTING
METERS
NETWORK
WASTE
BASED
PAPER
EXAMPLE
ISSUES
ASSESSMENT
WORK
PEOPLE
FIGURE
PARTICIPANTS
COUNTRIES
APPLICATION
PROJECT
SUPPLY
HOUSEHOLDS
Water

CITY
VARIOUS
IMPLEMENTATION
STANDARD
RECYCLING
MANAGEMENT
LIMITED
PRESENTED
COMMUNITY
ECONOMIC
PRACTICES
DESIGN
FOLLOWING
REFERENCE
CURRENT
DEVICES
LEVEL
NEED
DEVELOPMENT
INDUSTRY
NUMBER
TIME
EMISSIONS
MODEL
SOCIAL
SUSTAINABLE
SOCIETY
SERVER
GENERAL
LIFE
SMART
REDUCE
INCLUDED
INTERNATIONAL
ACTIVITIES
AVAILABLE
ENERGY
CREATE
GROUP
HTTP
IMPACT
MATERIAL
GREEN
ENVIRONMENT
BUSINESS
RESEARCH
WATER
ELECTRONIC
NEW
DATA
USE
USERS
MAKE
SOLUTIONS
MOBILE
RESULTS
SECTOR
MEASUREMENT
IMPORTANT
DIFFERENT
OPERATION
INCREASE
APPROACH
TECHNOLOGY
ASPECTS
INITIATIVES
RELATED
POTENTIAL
ELECTRICITY
HOME
PRODUCTION
CONSUMPTION
CARBON
REPORT
EFFICIENCY
ICT
CHANGE
STUDY
ACCESS
EFFECTS
POSSIBLE
CLIMATE
SERVICES
ORGANIZATIONS
SCENARIO
POWER
CASE
CONSUMERS
SOFTWARE
PROCESS
PROVIDE
BUILDING
REQUIRED
WASTE
BASED
NETWORK
SYSTEMS
COMPUTING
METERS
FIGURE
PAPER
EXAMPLE
ISSUES
ASSESSMENT
WORK
PEOPLE
PARTICIPANTS
COUNTRIES
APPLICATION
PROJECT
SUPPLY
HOUSEHOLDS

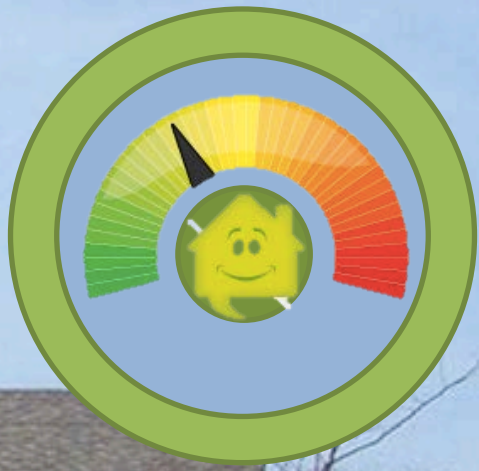


BROADENING THE CONVERSATION

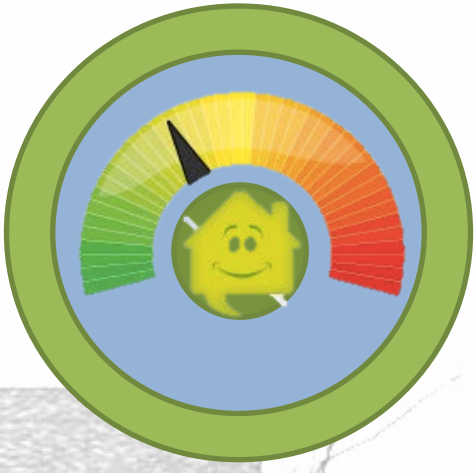
Carnegie Mellon

A common focus

- Smart Meters
- Feedback & Sensing
- Behavior Change



It feels good, but is it?



Carnegie Mellon

What is the potential positive impact of technology?

Remove **7.8**

$GtCO_2$ emissions

SMART 2020: Enabling the low carbon economy in the information age (smart2020.org)

Carnegie Mellon

What is the potential positive impact of technology?

Remove **7.8**

$GtCO_2$ emissions

Smart motors [.97 $GtCO_2e$]
Smart logistics [1.52 $GtCO_2e$]
Smart buildings [1.68 $GtCO_2e$]
Smart grids [2.03 $GtCO_2e$]

What is the potential positive impact of technology?

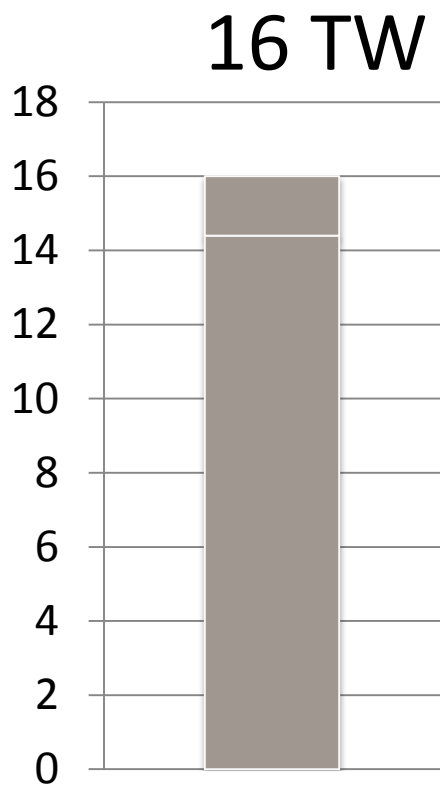
Remove **7.8**

$GtCO_2$ emissions

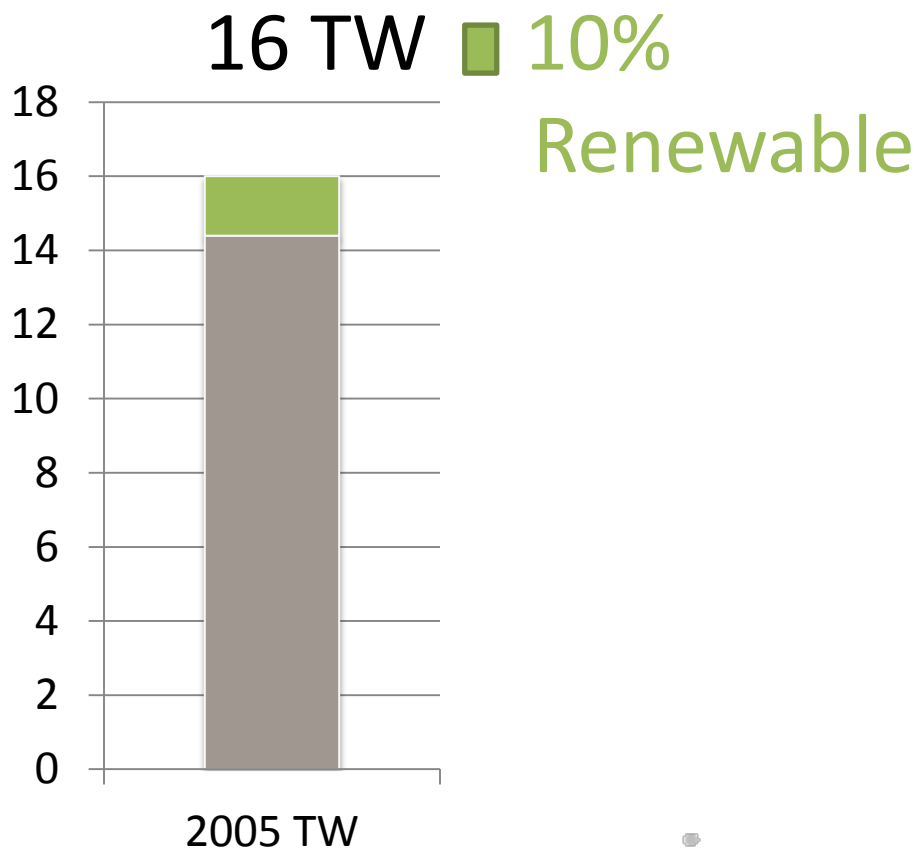
Smart motors [.97 $GtCO_2e$]
Smart logistics [1.52 $GtCO_2e$]
Smart buildings [1.68 $GtCO_2e$]
Smart grids [2.03 $GtCO_2e$] ← behavior change

What is the potential positive impact of technology?

2005 TW used



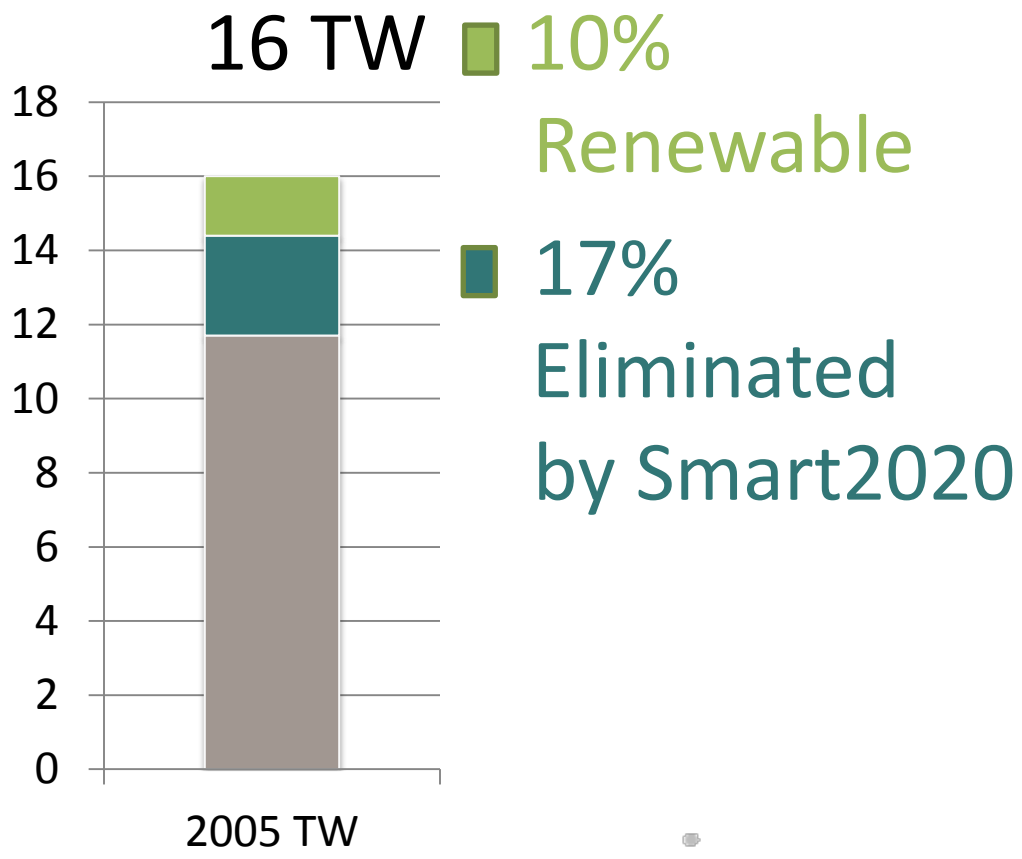
What is the potential positive impact of technology?



What is the potential positive impact of technology?

Remove **7.8**

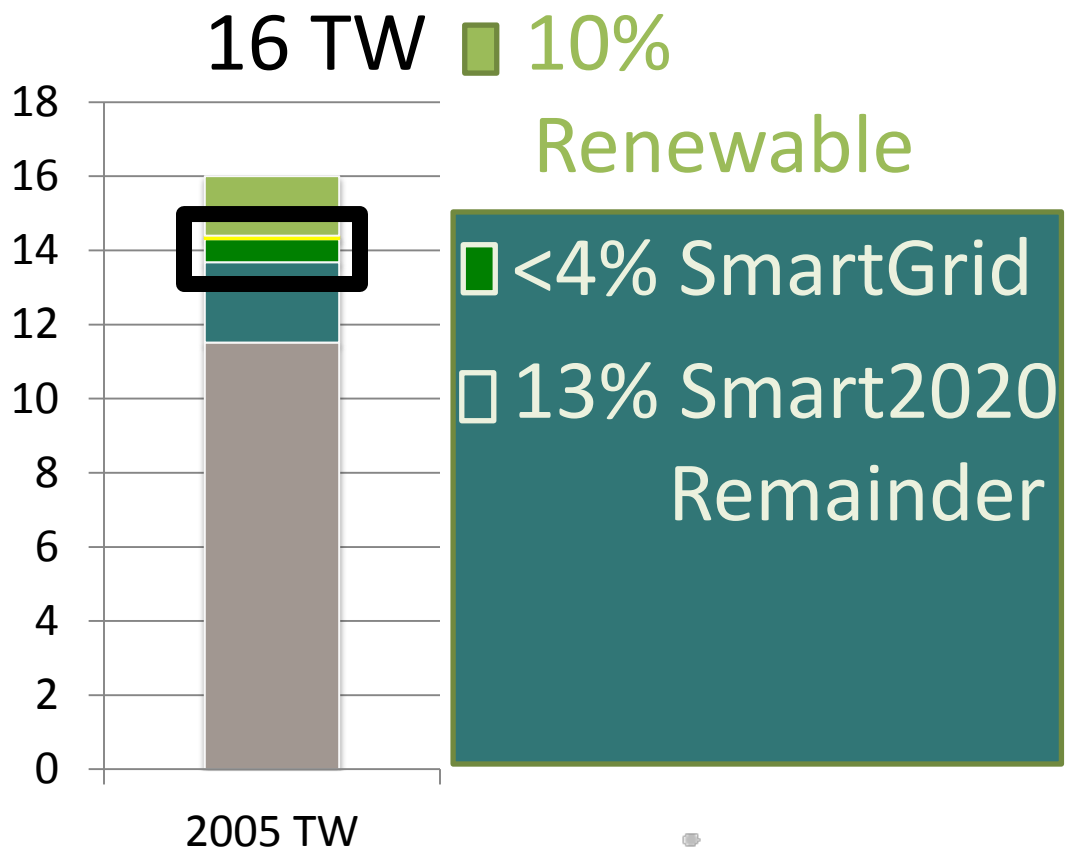
$GtCO_2$ emissions



Carnegie Mellon

What is the potential positive impact of technology?

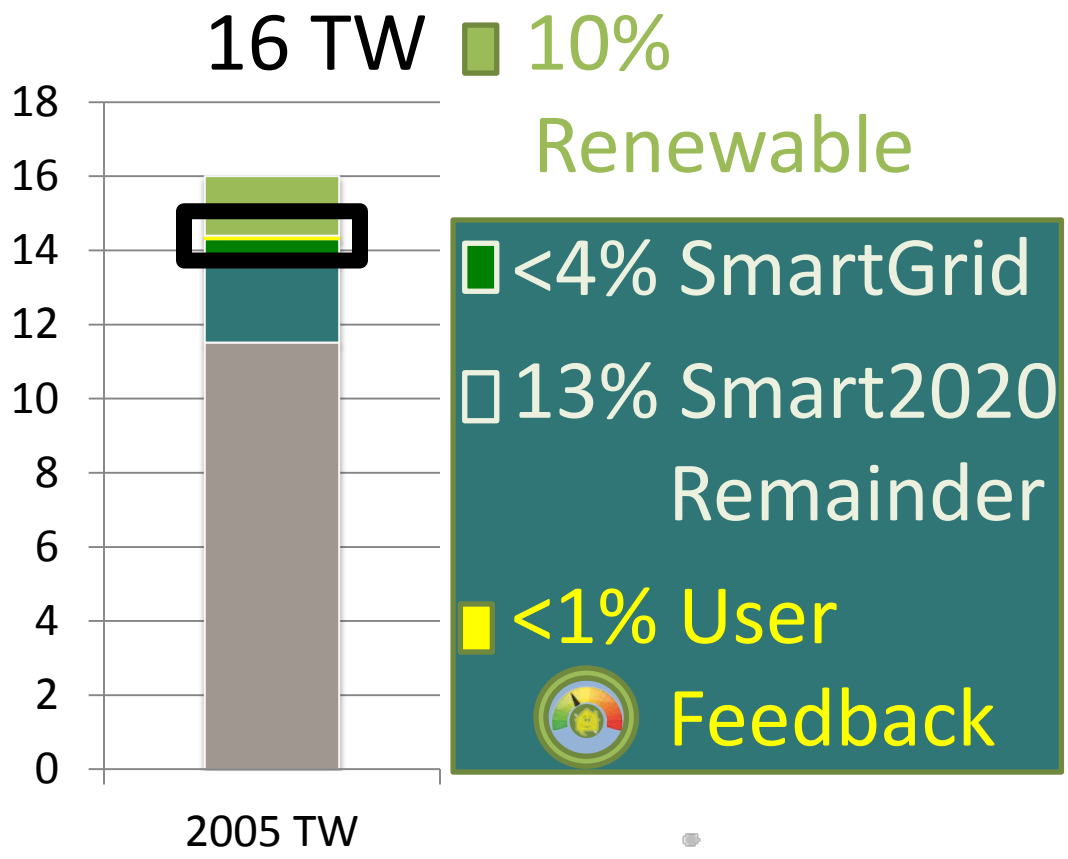
Remove **7.8** $GtCO_2$ emissions



What is the potential positive impact of technology?

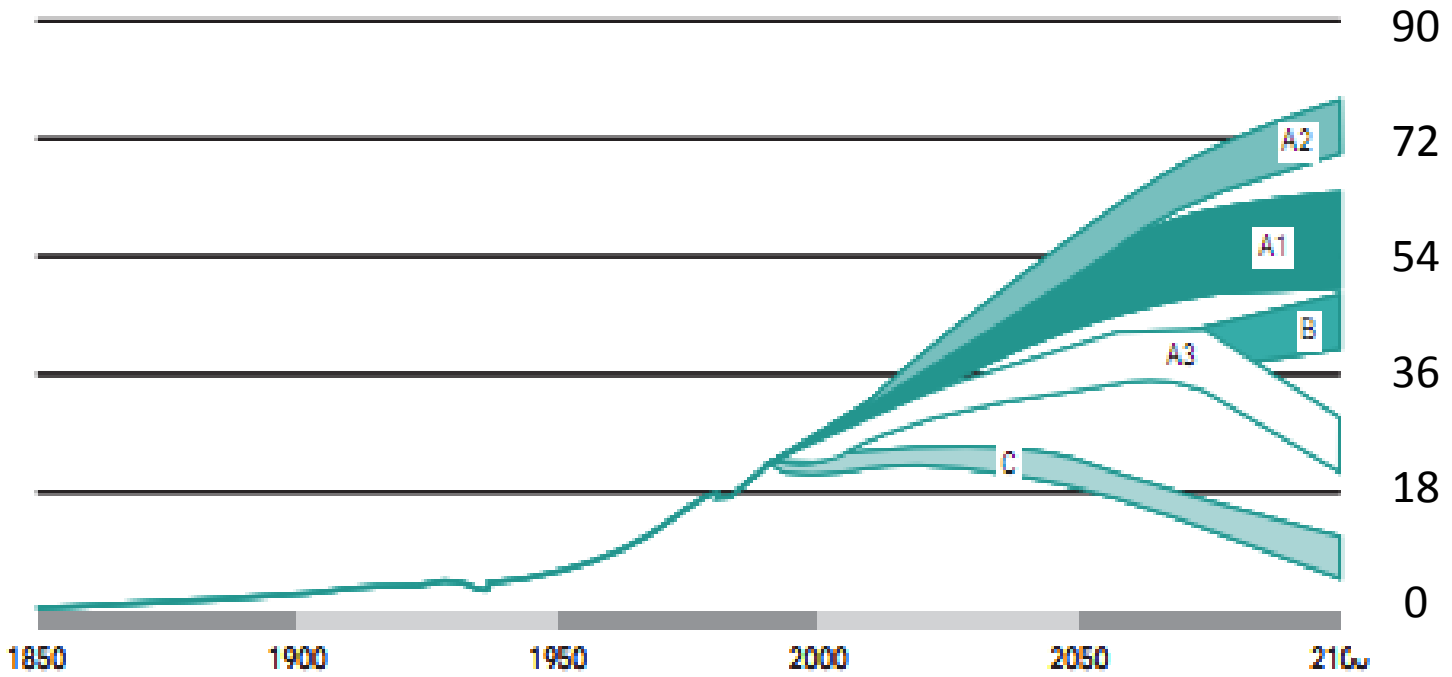
Remove **7.8**

$GtCO_2$ emissions



More Context:

Global carbon emissions from fossil fuel use, 1850-1990 and for the IIASA-WEC scenarios to 211 (In $GtCO_2e$)

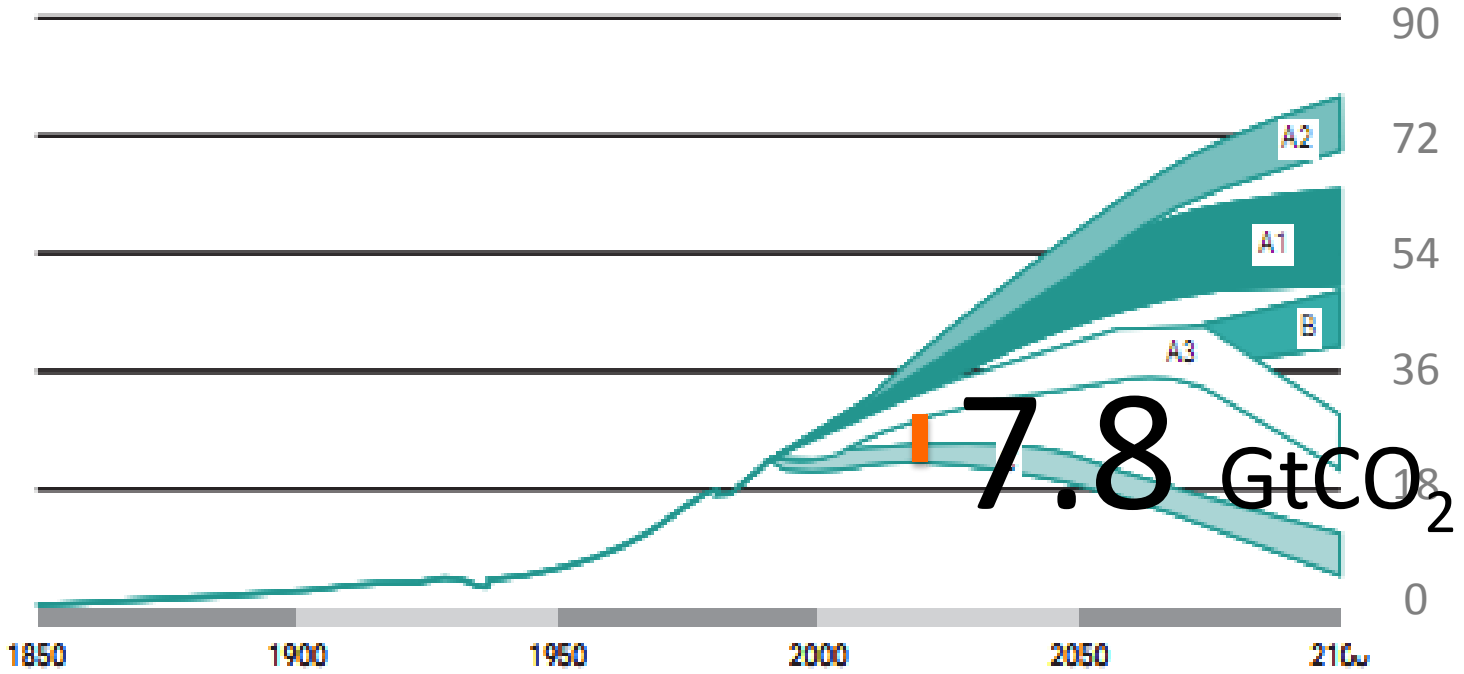


Note: For each scenario, the range shows the difference between gross and net emissions.

IPCC Report; http://www.oecd.org/dataoecd/37/55/17738498.pdf

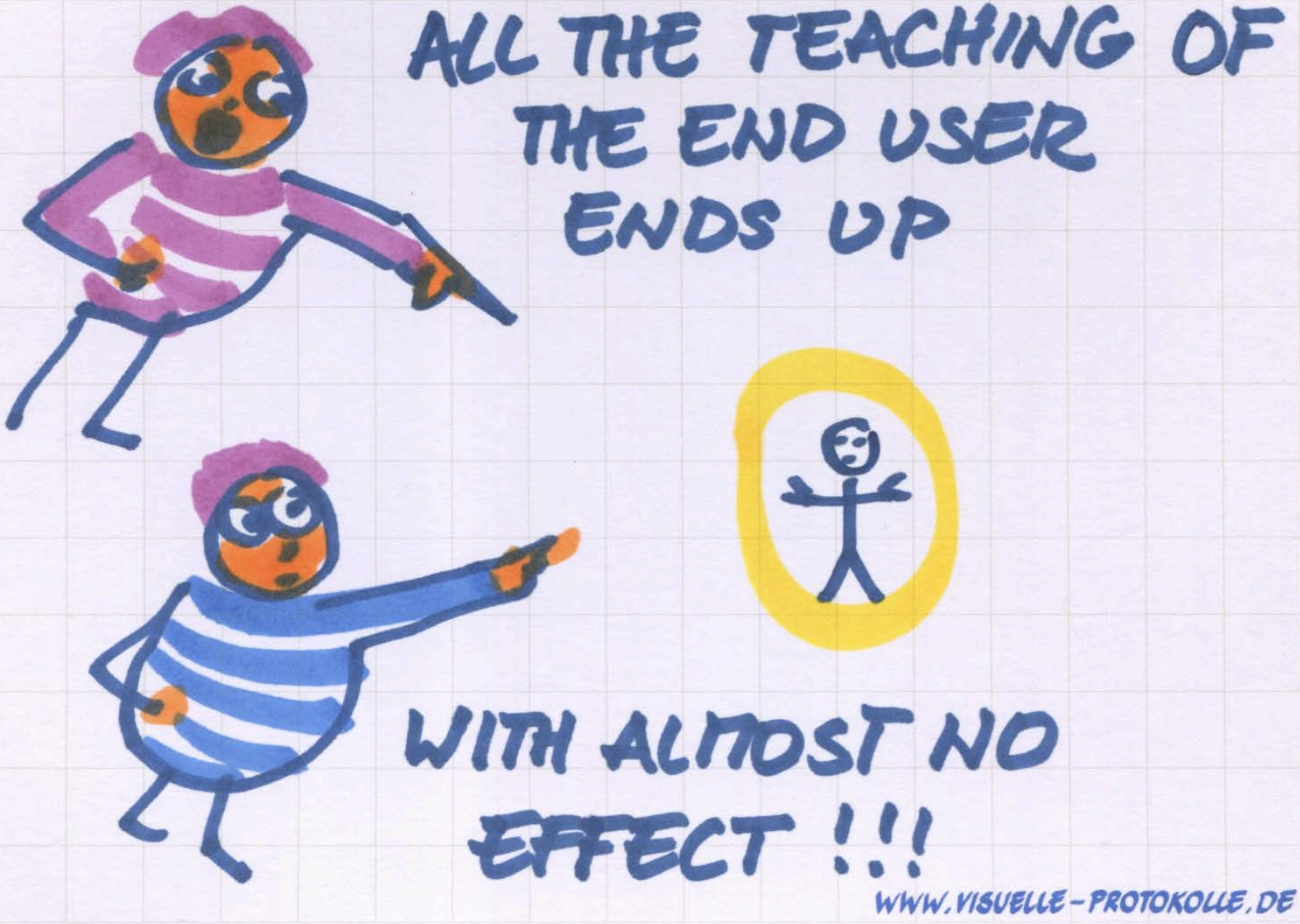
Carnegie Mellon

All of Smart2020



Note: For each scenario, the range shows the difference between gross and net emissions.

Carnegie Mellon


ALL THE TEACHING OF
THE END USER
ENDS UP
WITH ALMOST NO
EFFECT !!!
WWW.VISUELLE-PROTOKOLLE.DE

Measuribility, Audience, Environmentality, Scale

ALTERNATIVE:
BROADEN THE CONVERSATION

A broader focus for computational sustainability

- *Measure* impact

A broader focus for computational sustainability

- *Measure* impact
  - Direct Impacts: Waste & energy use
  - Indirect Impacts: Manufacturing, societal, …

Measuring Impact

- How can micro data help?
- How can macro data help?
- How do we model uncertainty?

- *BIG opportunity for IT*

Housing Sustainability

Carlson, Matthews, Berges

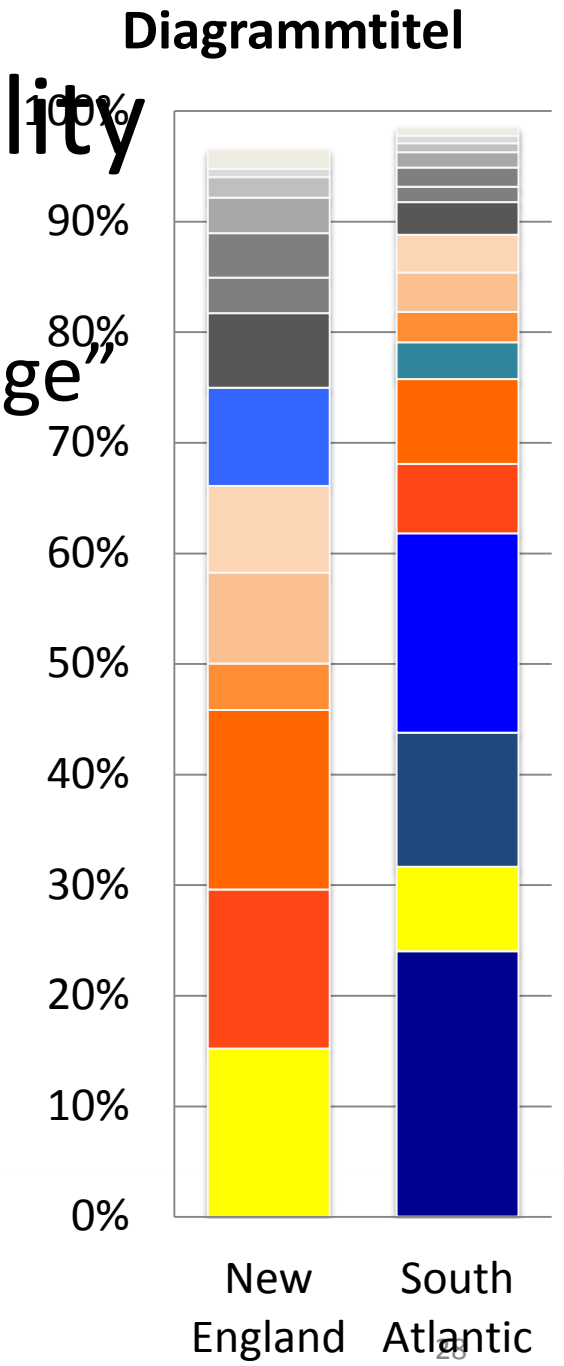
- Most analyses focus on an “average” (nationwide)
- But even breaking up by region makes a big difference in results

Carlson, D. R., Matthews, H. S., Bergés, M. E., (2013). One Size Does Not Fit All: Averaged Data on Household Electricity is Inadequate for Residential Energy Policy and Decisions. Energy and Buildings, In Review.

Housing Sustainability

Carlson, Matthews

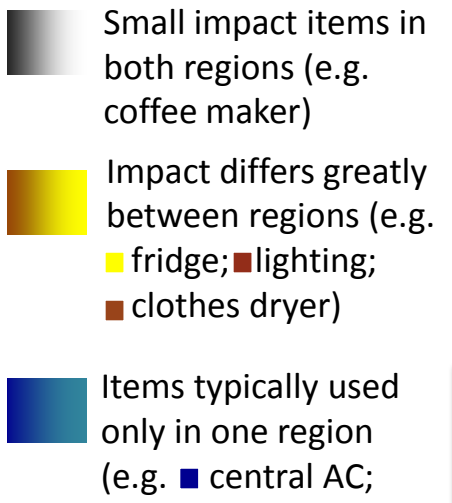
- Most analyses focus on an "average" (nationwide)
- But even breaking up by region makes a big difference in results, *e.g.*,

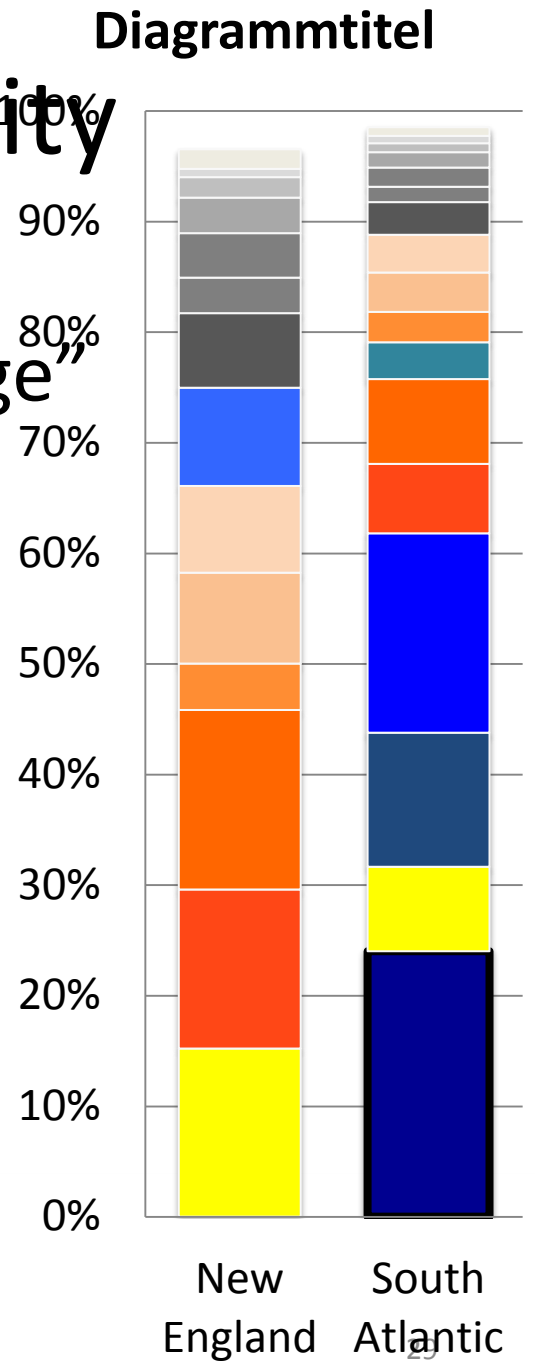


Housing Sustainability

Carlson, Matthews

- Most analyses focus on an "average" (nationwide)
- But even breaking up by region makes a big difference in results, *e.g.*,

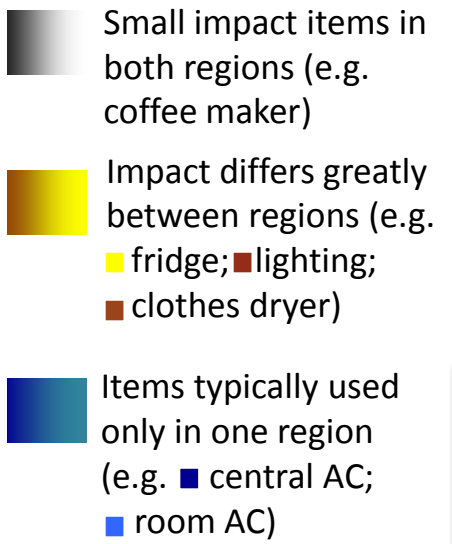


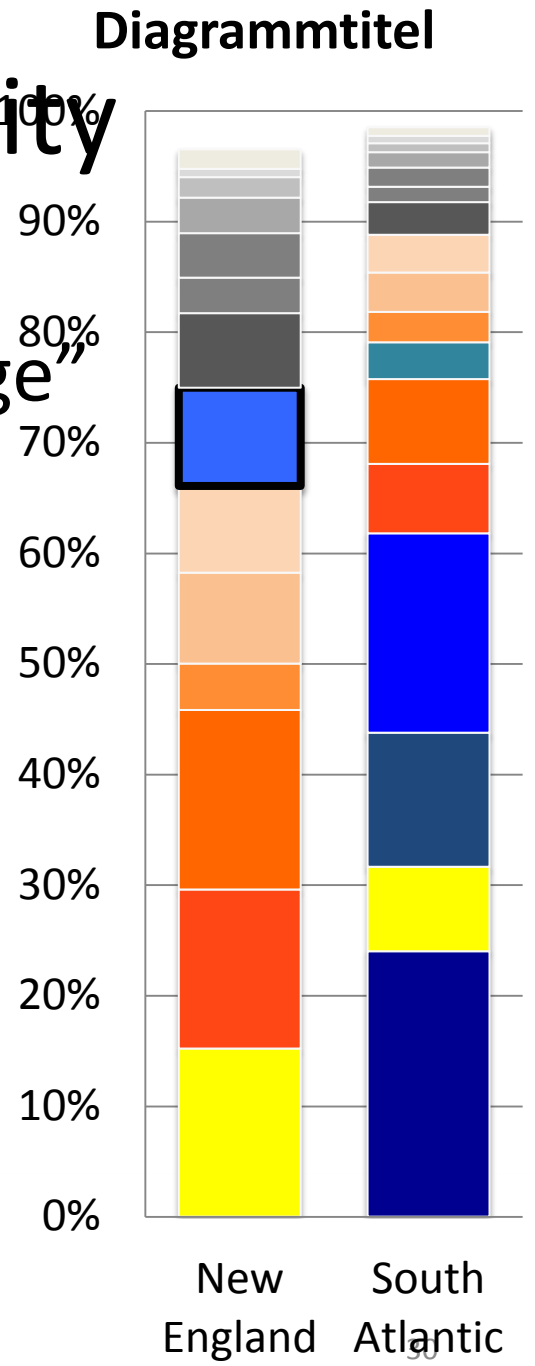


Housing Sustainability

Carlson, Matthews

- Most analyses focus on an "average" (nationwide)
- But even breaking up by region makes a big difference in results, *e.g.*,



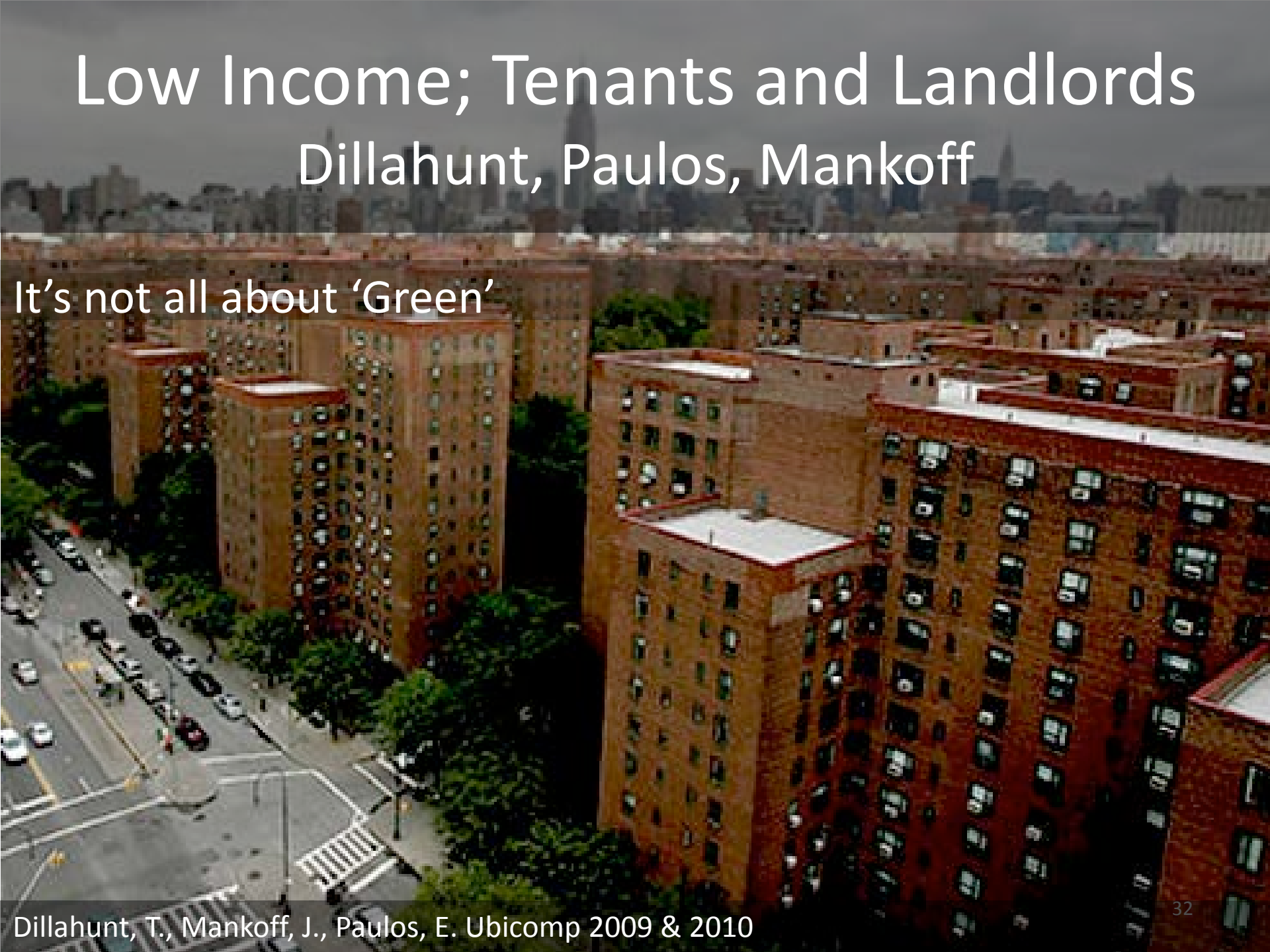


A new focus for computational sustainability

- *Measure* impact
- *Expand the audience*
  - governments as well as individuals
  - multiple sectors and cultures

Low Income; Tenants and Landlords

Dillahunt, Paulos, Mankoff



Dillahunt, T., Mankoff, J., Paulos, E. Ubicomp 2009 & 2010

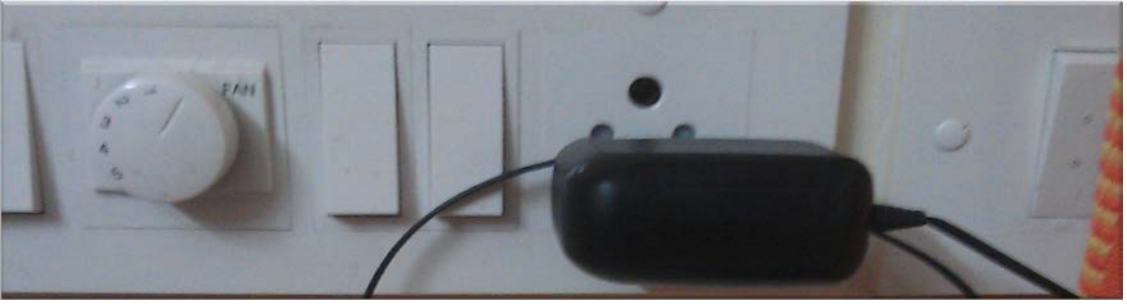
Crossing Cultures

Srinivasan, Jain, Seetharam, Mankoff *et al.*

Shrinivasan, Y., Jain, M., Seetharam, D., Choudhary, A., Huang, E., Dillahunt, T., Mankoff, J. (CHI 2013)

Water re-use (multiple tiers) *"I use like two mugs for shaving, it's a routine thing… so no runoff of*

Carnegie Mellon



Every device, large or small, has a switch

The middle pot is using the dissipated heat

An earthenware vessel for smashing grains replaces a blender

Using broomsticks for sweeping floors manually: energy efficient and healthy

Carnegie Mellon

Implications for Design

- Built-in point of use feedback
- Modularizing use
- Opportunistic resource consumption
- Multiplying use by harnessing by-products
- Automatic load shifting

A broader focus for computational sustainability

- *Measure* waste and impact
- *Expand the audience*
- *Encourage* environmentality, not just efficiency

Encourage Environmentality

Agarwal's environmentality

Agarwal, A. Environmentality: Community, intimate government, and the making of environmental subjects in Kumaon, India. *Current Anthropology*, 2005

Foucault, M. (1994). Governmentality

"framing sustainability solely in terms of personal moral choice in a marketplace of consumption options may obscure the broader political and regulatory questions that attend significant change." -- Dourish [DIS '10]

IT just beginning to touch these areas (e.g. "twitter revolution")

Dourish, P. HCI and Environmental Sustainability: The politics of design and the design of polit
DIS 2010

Carnegie Mellon

A broader focus for computational sustainability

- *Measure* waste and impact
- *Expand the audience*
- *Encourage* environmentality, not just efficiency
- *Scale up* to governments, nations or more

HOW *SHOULD* WE MEASURE IMPACT?

A new checklist for IT sustainability work

- Measure:
  - Direct impact on problem
  - Indirect impact on sustainability problem
  - Waste

A new checklist for IT sustainability work

- Measure:
  - Direct impact on problem
  - Indirect impact on sustainability problem
  - Waste
- Expand the Audience:
  - How will it be implemented within or across nations?
  - How will it influence national trends (*e.g.,* growth)
  - How will it integrate within a cultural context?

A new checklist for IT sustainability work

- Measure:
  - Direct impact on problem
  - Indirect impact on sustainability problem
  - Waste
- Expand the Audience:
  - How will it be implemented within or across nations?
  - How will it influence national trends (*e.g.,* growth)
  - How will it integrate within a cultural context?
- Encourage Environmentality
  - How does this help to change the relationship between citizens, government and the environment?

A new checklist for IT sustainability work

- Measure:
  - Direct impact on problem
  - Indirect impact on sustainability problem
  - Waste
- Expand the Audience:
  - How will it be implemented within or across nations?
  - How will it influence national trends (*e.g.*, growth)
  - How will it integrate within a cultural context?
- Encourage Environmentality
  - How does this help to change the relationship between citizens, government and the environment?
- Scale (and scalability) of impact
  - At what scale must this be deployed to have impact?
  - How could that be achieved?

We have to push harder

Feel-good motivations are not enough

Smart meters are not enough

Let's make words like water, international & policy the big focus!

Thank you

Questions?

jmankoff@cs.cmu.edu

scsgreen.cs.cmu.edu

Collaborators: Matthews, Paulos, Fussell, Seetharam, Dey, Dillahunt, Koehler & more

Graphic Design: Peiqi Su

Funders:

Google

intel Leap ahead

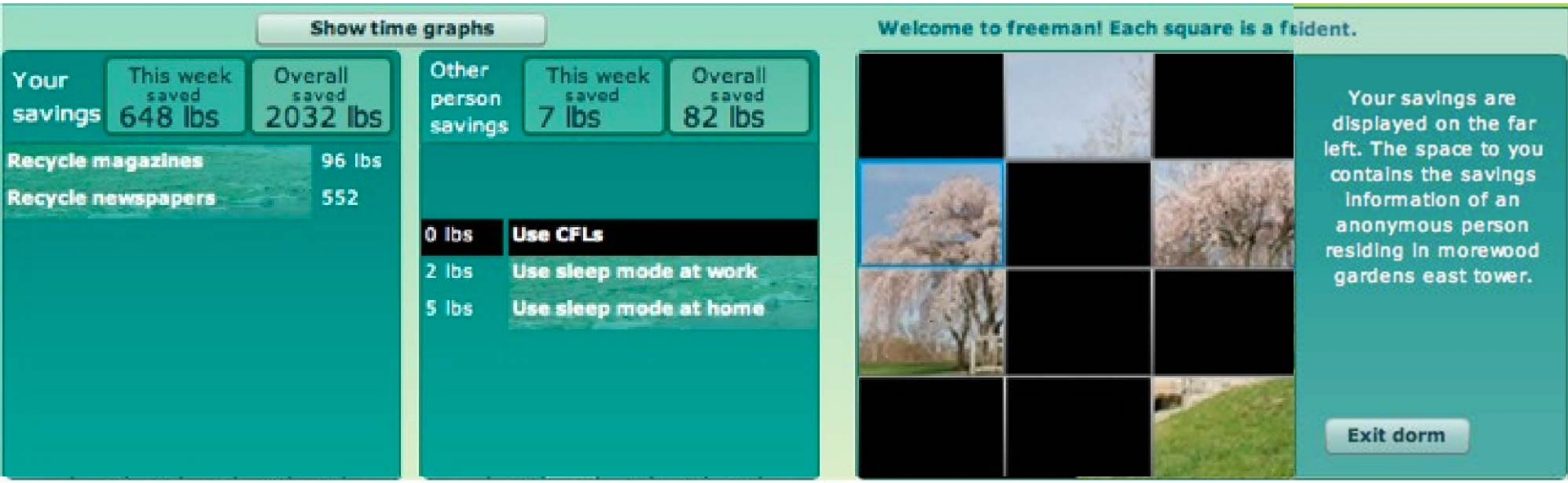
NSF

Comparative Visualization

Comparative Visualization

Carnegie Mellon

Comparative Visualization



Carnegie Mellon

Comparative Visualization

"I liked being able to compare myself to others and my previous output because it helped me determine how much energy I was saving"

"limited number of actions you can commit to does not fit well with college life style (many actions not applicable)"

"the way that was set up--each dorm/place making up a picture, and then each person within that—really clever and beautiful"

Actions that don't change

Rank	Already Do	Unappealing
1	Turn out lights when leaving home (16%)	Install motion sensors for some lights (5%)
2	Use a manual toothbrush (12%)	Turn off and unplug devices at work (5%)
3	Turn out lights when leaving a room (12%)	Volunteer time (5%)

Popular, High Impact New Actions

Name	Impact
Set your home computer to sleep	617 lbs CO_2/yr
Recycle aluminum	116 lbs CO_2/yr
Adjust your water heater thermostat to 120F	1242 lbs CO_2/yr

UbiGreen

Froehlich, Landay, Dillahunt Mankoff

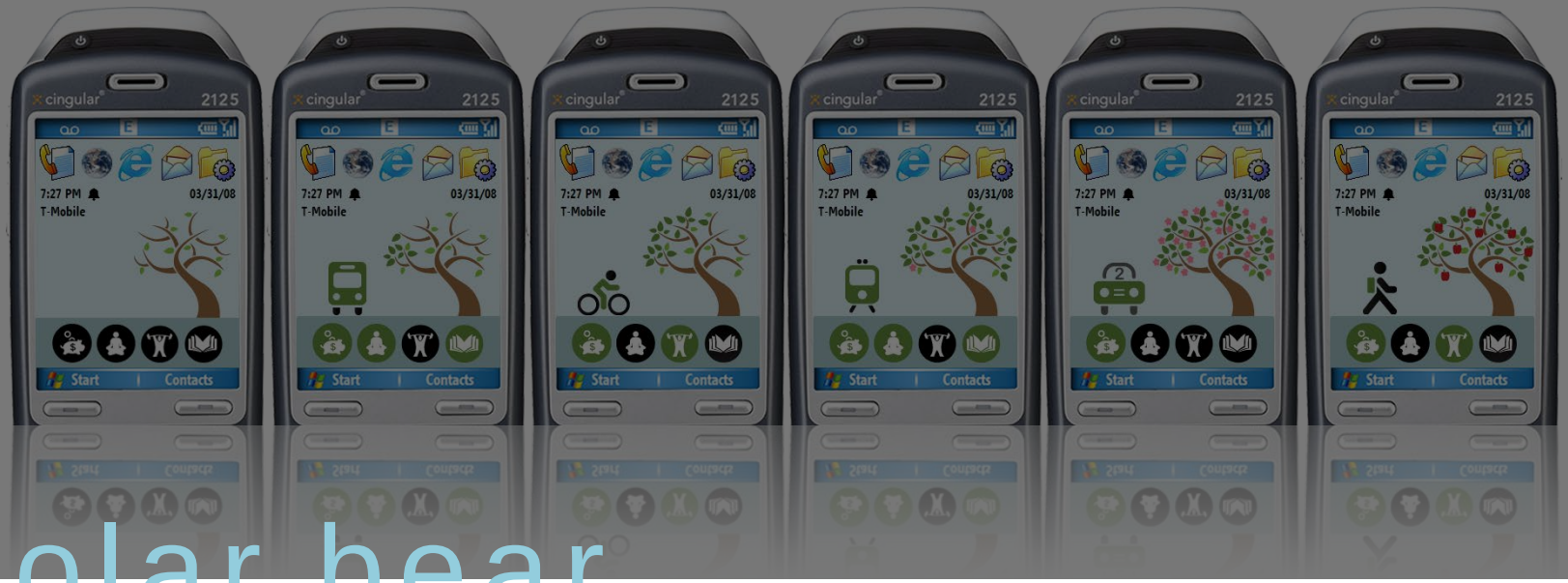
- Mobile, sensed green actions
- Focused on transportation
- Design based on two formative studies
- Three week field deployment

everything resets on sunday

Carnegie Mellon

Carnegie Mellon

tree



polar bear

3-week Field Study

- 2 cities; 14 participants
- Obtain preliminary feedback on prototype
  - Engagement
  - Potential for social use
  - Potential for changing behavior

Engagement

"It's omnipresent"

- Participant 9

"I want to have different stories every week … to maintain curiosity in the app"

- Participant 8

Real-life game

One participant complained that when a trip hadn't been automatically recorded, "I felt like I was being cheated out of my 'points'"

- Participant 2

Social

"Some people at work knew about the polar bear and every day they asked me about it. 'Did you get a seal today?'"

- Participant 14

Carnegie Mellon

Potential For Behavior Change

“It really encourages you to analyze your own performance”

- P8: Introspection

“I feel I already travel in a relatively eco-friendly way and the study did not change that

- P2: “too green”

“This can be connected with government incentives somehow… For example, government could encourage people with tax refund.”

- P7: Looking for impact

Carnegie Mellon

stepgreen enrich your life.

carbonrally.com®
Small actions. Big impact.

GoodGuide BETA

stopglobalwarming.org

treehugger
A Discovery Company

YOUR (LIL) GREEN PATCH

YAHOO! GREEN

energyrace
make a difference. measure it here.

GreenNexxus
Where green minded people meet

Carnegie Mellon

stepgreen enrich your life.

Fussell, Matthews, Matthews, Mankoff, …

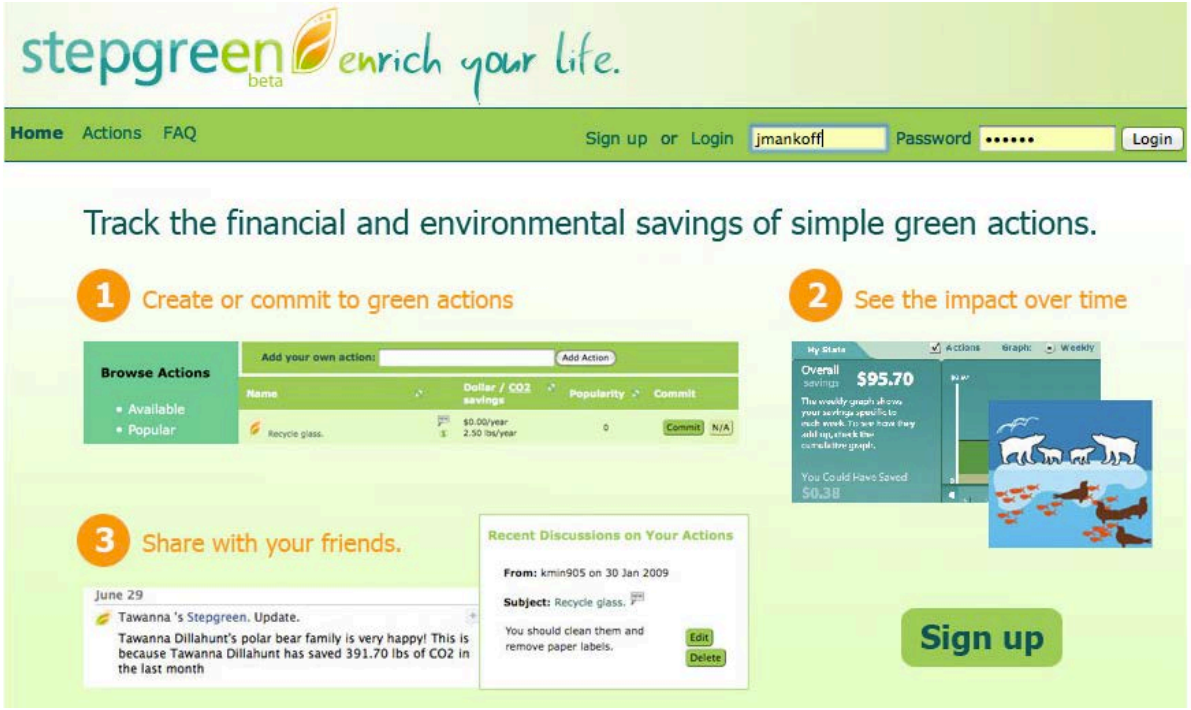
- Piggyback on social websites
- Compare types of motivation
- Explore new visualizations
- Evaluate scalability

Carnegie Mellon

Research-Driven Design

Clients ⟷ **Server**: External API

Facebook
Android
…



J. Mankoff, S. R. Fussell, T. Dillahunt, R. Glaves, C. Grevet, M. Johnson, D. Matthews, H. S. Matthews, R. McGuire, R. Thompson, A. Shick and L. Setlock, ICWSM 2010.

Grevet, C., Mankoff, J. and Anderson, S. D. (2010). HICSS 2010.

Many open deployments

1. First ever CMU dorm study
2. Zoo Pittsburgh neighborhood competition
3. Wellesley comparative visualization
4. Pittsburgh Green Business competition
5. Going Mobile

Carnegie Mellon

Many open deployments

1. First ever CMU dorm study
2. Zoo Pittsburgh neighborhood competition
3. Wellesley comparative visualization
4. Pittsburgh Green Business competition
5. **Going Mobile**

Carnegie Mellon

Direct Impact

- Direct impacts
  - Efficiency (new tech, new patterns of use, better buildings, *etc.*)
  - Waste capture, storage, & reuse
  - Renewable sources

Socolow & Pacala http://ngm.nationalgeographic.com/2007/10/carbon-crisis/img/stabilization_wedges.pdf;

A. Gore, *Earth in the Balance*

Examples

- Direct impacts
  - Efficiency (new tech, new patterns of use, better buildings, *etc.*)
  - Waste capture, storage, & reuse
  - Renewable sources

Carbon capture

Reforestation

Better energy grid

Socolow & Pacala http://ngm.nationalgeographic.com/2007/10/carbon-crisis/img/stabilization_wedges.pdf;

A. Gore, *Earth in the Balance*

Indirect Impact

- Direct impacts
  - Efficiency (new tech, new patterns of use, better buildings, *etc.*)
  - Waste capture, storage, & reuse
  - Renewable sources

- Indirect impacts
  - Manufacturing & Distribution
  - Population control
  - Economic controls
  - Cultural Relevance
  - Education
  - Governmental
  - Advancing science

Socolow & Pacala http://ngm.nationalgeographic.com/2007/10/carbon-crisis/img/stabilization_wedges.pdf;

A. Gore, *Earth in the Balance*

Examples

Life Cycle Analysis

Carbon Taxes

Simulation tools

Advocacy

- Indirect impacts
  - Manufacturing & Distribution
  - Population control
  - Economic controls
  - Cultural Relevance
  - Education
  - Governmental
  - Advancing science

Socolow & Pacala http://ngm.nationalgeographic.com/2007/10/carbon-crisis/img/stabilization_wedges.pdf;

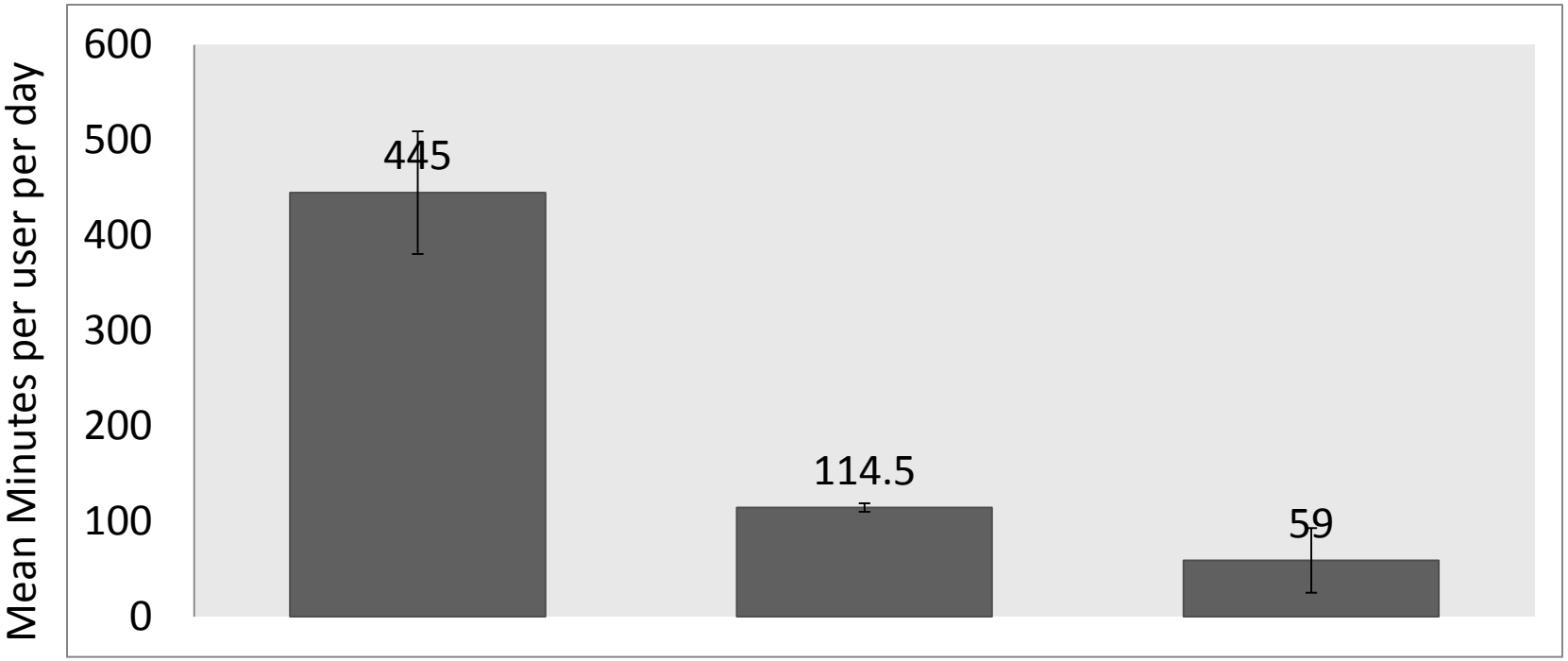
A. Gore, *Earth in the Balance*

Example: When does heating happen?

Dey, Koehler, Mankoff

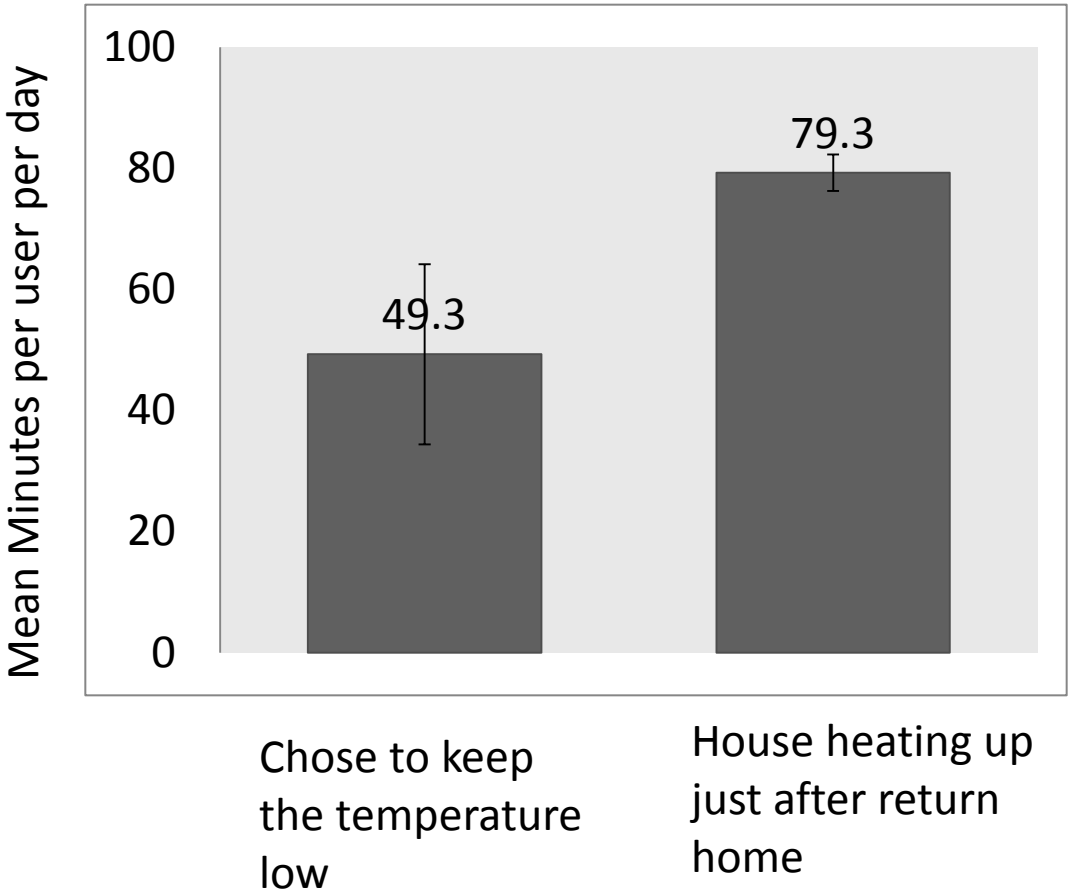
- 10 participants
- GPS tracking
- Smart Thermostat

Common uses of heating



Carnegie Mellon

When can we *not* heat



Carnegie Mellon