ICT for Sustainability

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1 **Energy Efficiency**
Doing more useful things
with less energy input

2 **Closing Material Cycles**
Thinking in material flow systems

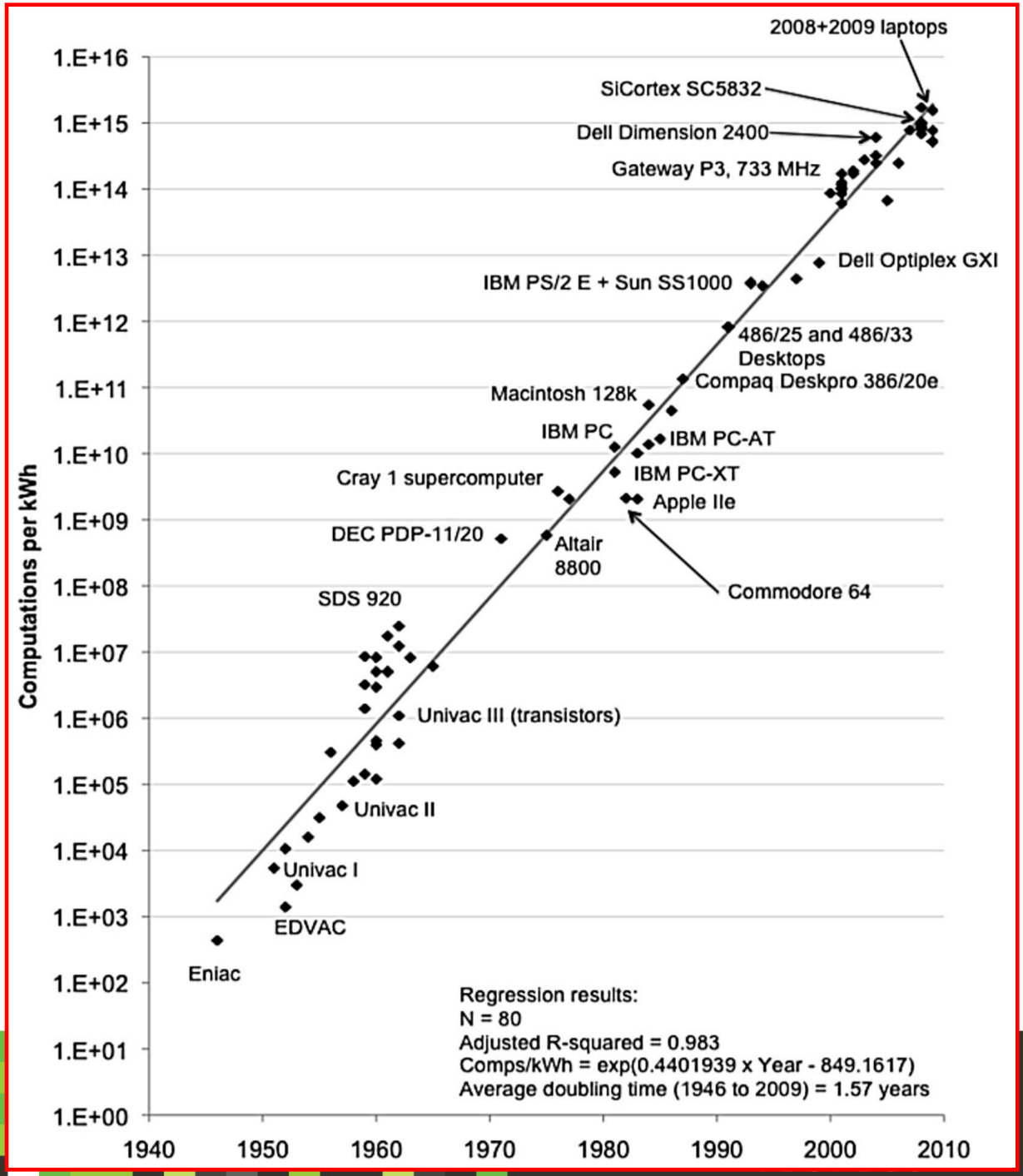
3 **Decoupling**
How ICT can help to limit resource consumption

Energy Efficiency
Doing more useful things
with less energy input

Energy efficiency in computing develops according to "Koomey's Law".

The number of **Computations per kWh** has doubled every 1.57 years from 1946 to 2009.

Source: Koomey et al. (2011)



What about energy efficiency in transferring data?

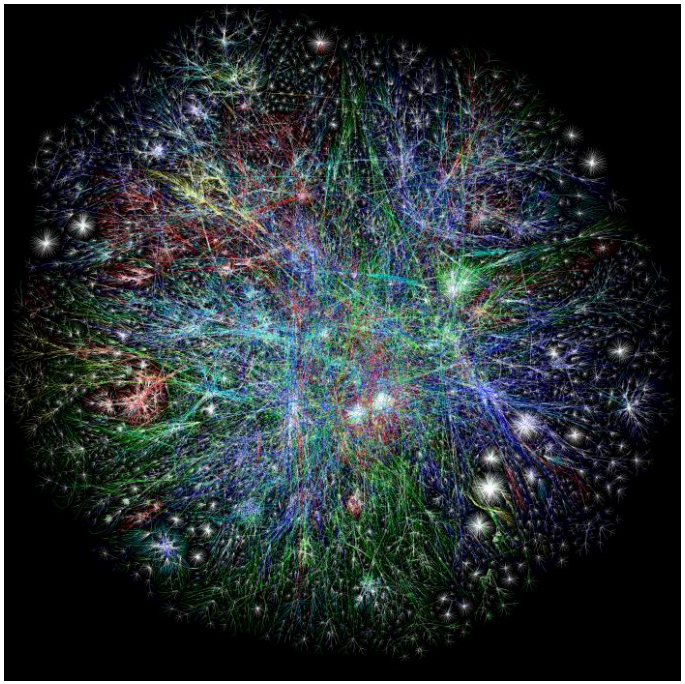
Which of these numbers represents the energy efficiency of the Internet?

A: **7** MB / kWh

B: **144** MB / kWh

C: **556** MB / kWh

D: **5000** MB / kWh



Source: Coroama et al. (2013)

Case study on videoconferencing:
The first World Resource Forum 2009 held in Davos and Nagoya

World Resources Forum

Davos, Switzerland

Nagoya, Japan

Two venues, one audience

Source: Coroama et al. (2011)

Eye contact during Q&A sessions

Source: Coroama et al. (2011)

Informal communication during breaks

Source: Coroama et al. (2011)

Case study result:
Videoconferencing was compensated by less than 1 flight

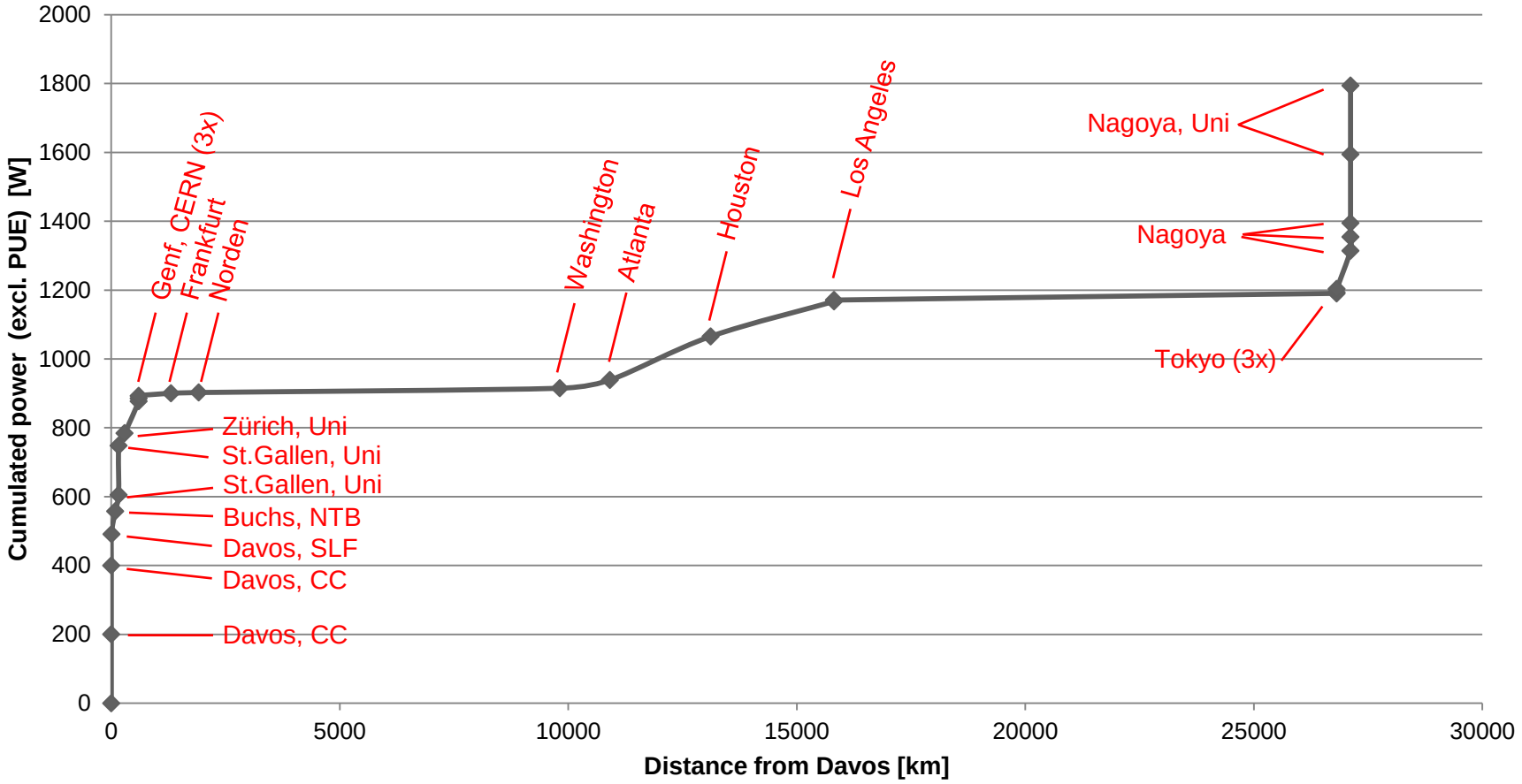
Davos, Switzerland

Nagoya, Japan

8 Channel Full-HD Videoconferencing, 12 h (for all participants in total)	**165 kg of** CO2
1 flight Zurich-Nagoya and back (for 1 person)	**2.1 - 3.7 tons** of CO2

Source: Coroama et al. (2013)

Cumulated electric power used to transport our signal over 27117 km on the Internet



Conclusions: Energy efficiency

- The energy cost of computation and telecommunication has dramatically *de*creased over the last decades.

- All activities with an informational aspect have the potential to become more energy efficient due to this development.

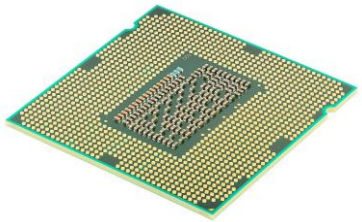
Closing Material Cycles
Thinking in material flow systems

Progress in density ("Moore's Law")

1971

Intel 4004
2300 transistors

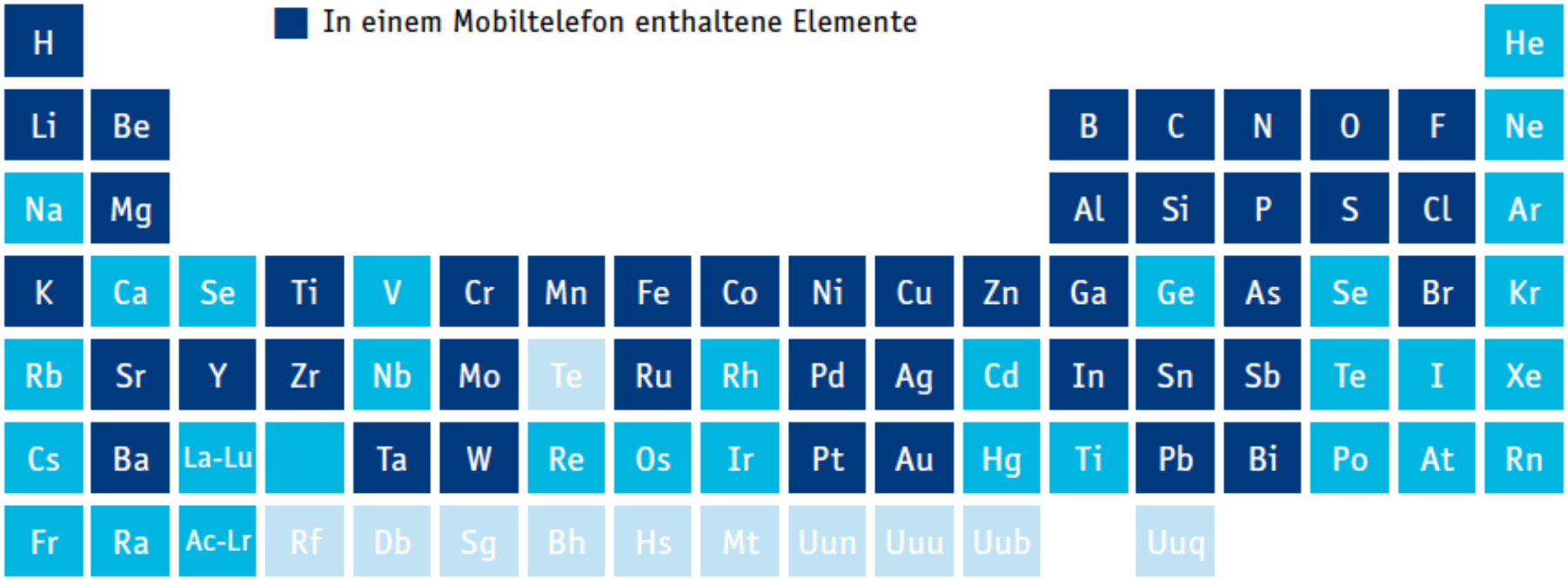
2011



Intel CORE i7 3960X
2,27 Billion transistors

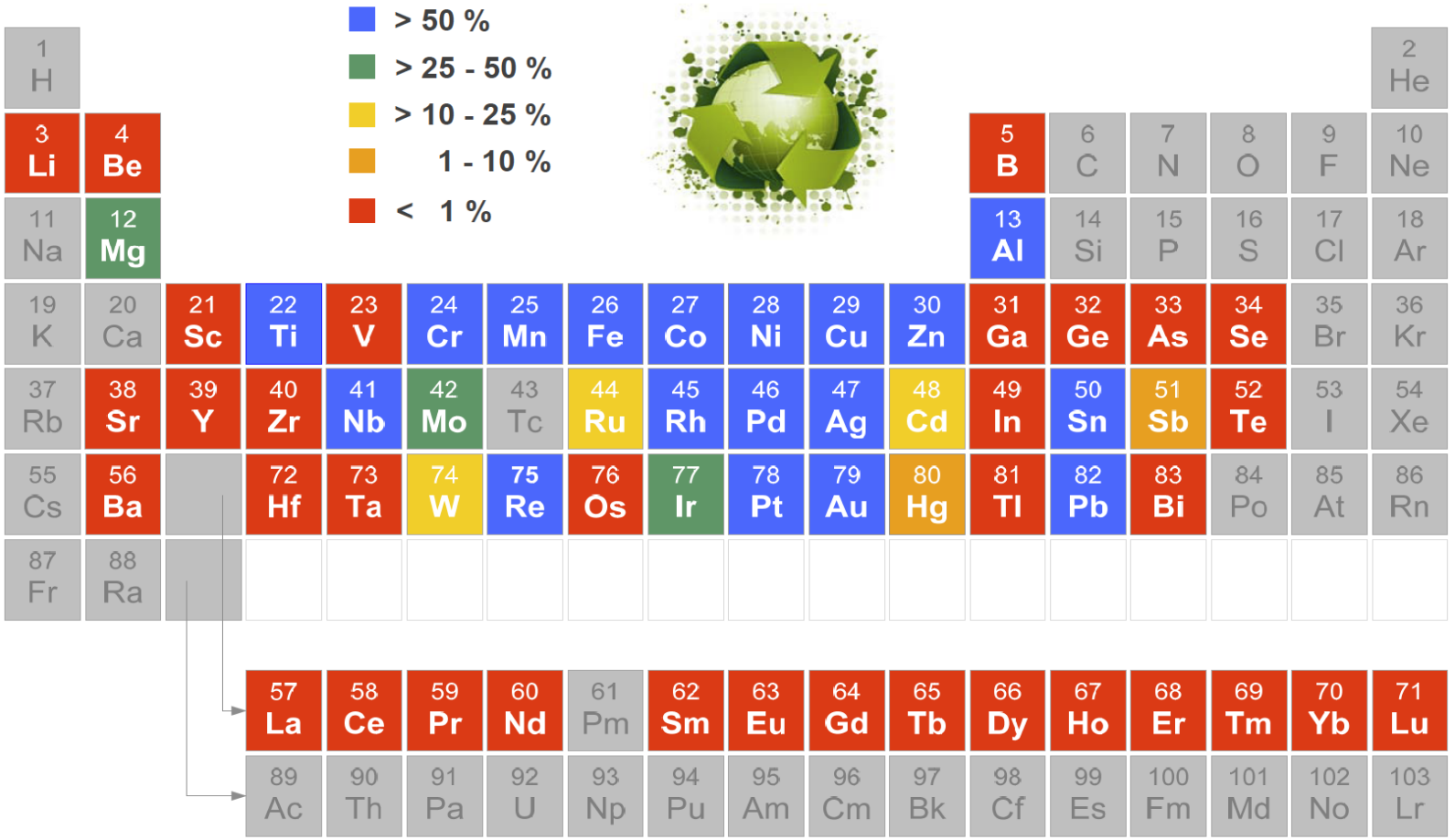
This progress has a price: increasing material complexity

Example: Chemical elements contained in a mobile phone



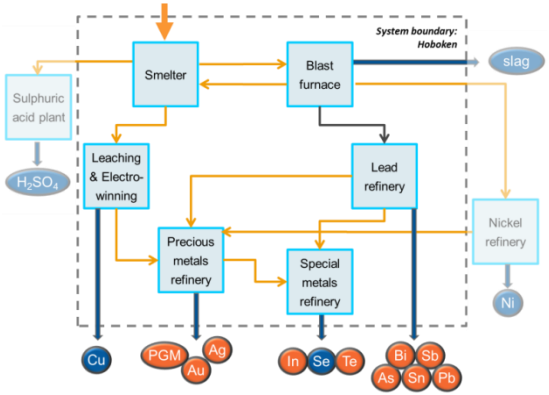
Source: Wäger et al. (2010)

Global recycling rates of elements in industrial use



Source: UNEP (2011)

Formal and informal e-waste recycling around the world



Source: Empa

We need more systems thinking if we want to keep the earths material stock valuable for future generations.

Sustainability is *not* a property of a **material**, a **process,** or a **product.**

It is the property of a **system** that provides some **services** to us. The system consists, among other things, of processes transforming materials in closed loops, keeping the energy efficiency of the cycles as high as possible.

"The laws of thermodynamics are carved into stone, the laws of the economy are written on paper."

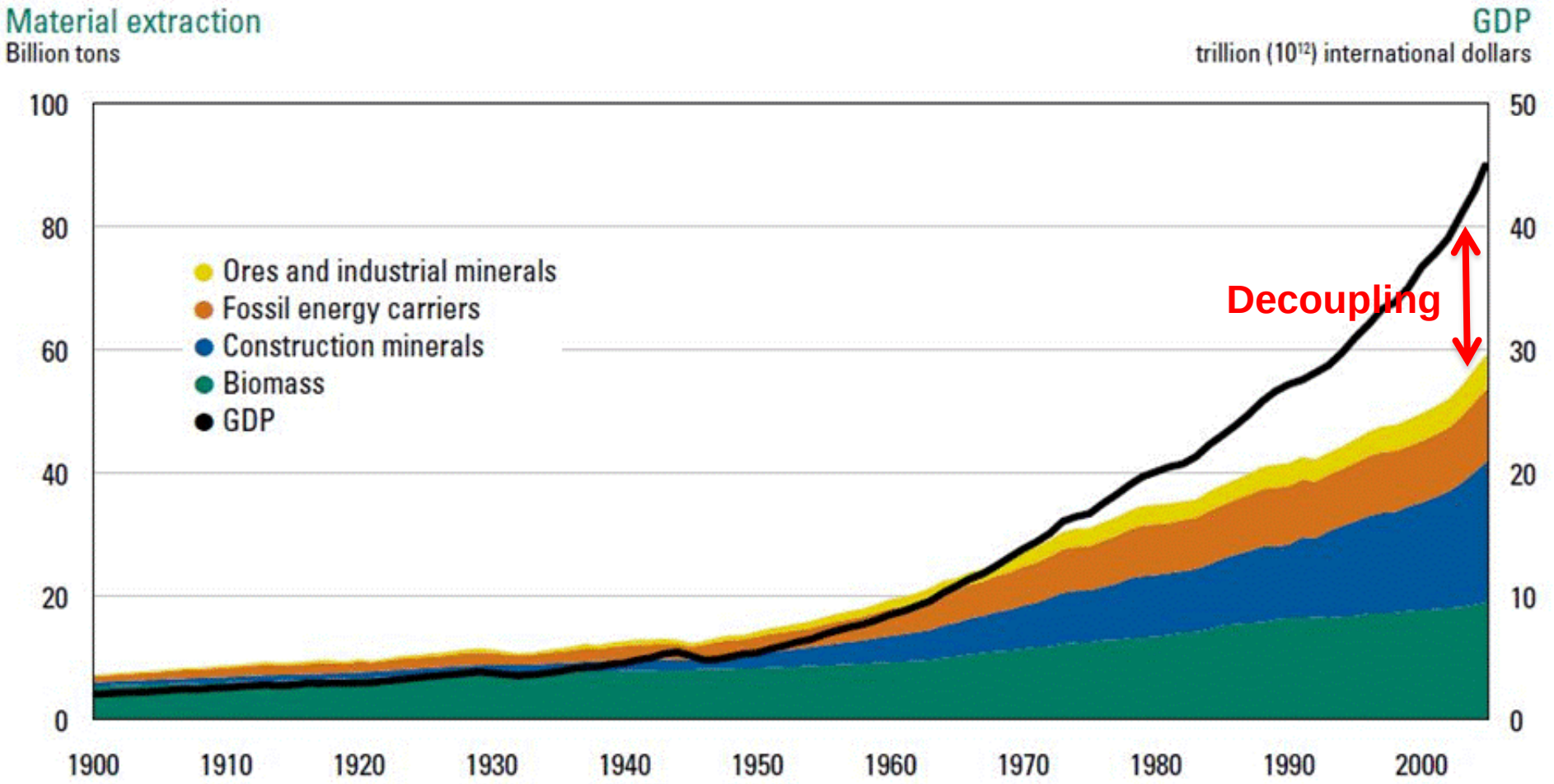
Roland Clift, President of the International Sociey for Industrial Ecology, in his speech at the World Resources Forum 2013 in Davos, Switzerland

Conclusions: Closing material cycles

- The unprecedented material complexity of ICT hardware is a challenge to sustainable material use.
- This challenge requires systems thinking in terms of material cycles.
- If the ICT sector finds solutions for sustainable material use, they well be solutions also for other sectors.

Decoupling

How ICT can help to limit resource consumption



Global Material Extraction in billion tonnes, 1900 – 2005; Krausmann et al. 2009 (in UNEP 2011)

Decoupling

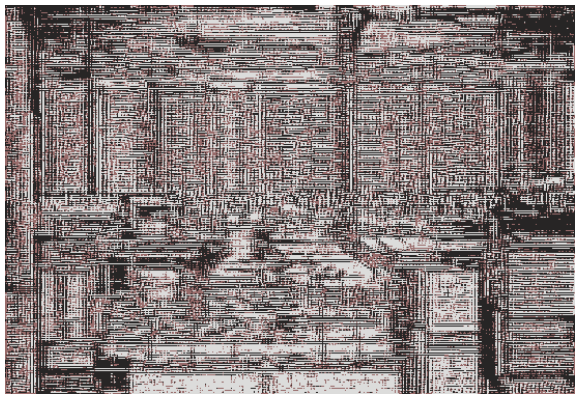
- ICT contributes to decoupling wherever value is created by assembling bits and not atoms.
- The current decoupling rate is not sufficient: global material extraction is too high and still increasing (albeit slower than GDP).
- The current decoupling rate is much smaller than would be technically possible: the rebound effect compensates for a large part of the theoretical potential.

Rebound effect example 1: ICT hardware revisited

Energy efficiency and price1971-2011

Electric power needed per transistor:
Decreased by a factor of **5000**

Price per transistor:
Decreased by a factor of **50 000**



Computing capacity becomes more efficient in terms of electricity, but even faster in terms of money.

→ That's why we are wasting computing capacity.

Rebound effect example 2: Smart vending machines

- Inefficient machines in the 1990s, consuming, e.g,. 3.7% of all electricity in Japan

- Smarter machines were developed

Features:

- Intelligent energy management
- Monitoring and forecasting the ambient temperature
- Motion detectors to sense the presence of potential customers
- Remote monitoring for optimized servicing

→ Saves up to 50% of energy per machine

Examples of reporting about smart vending machines when they were new

Did You Know?

A typical vending machine meeting the ENERGY STAR criteria will save more than 1,500 kWh per year compared with non-qualified models.

Learn how your facility can save with ENERGY STAR qualified vending machines

Come learn ways your organization can save money with ENERGY STAR vending machines by listening to the "Always Count Your Change: How ENERGY STAR Refrigerated Vending Machines Save Your Facility Money and Energy" webinar hosted by EPA's Una Song. (View Transcribed Version) (76KB)

Smart machines save energy:

Vending machine innovations slake thirst for savings

By Alvin Powell
Gazette Staff

The vending machines in Holyoke Center won't pour your soda for you, but they know you're there.

Quick Facts

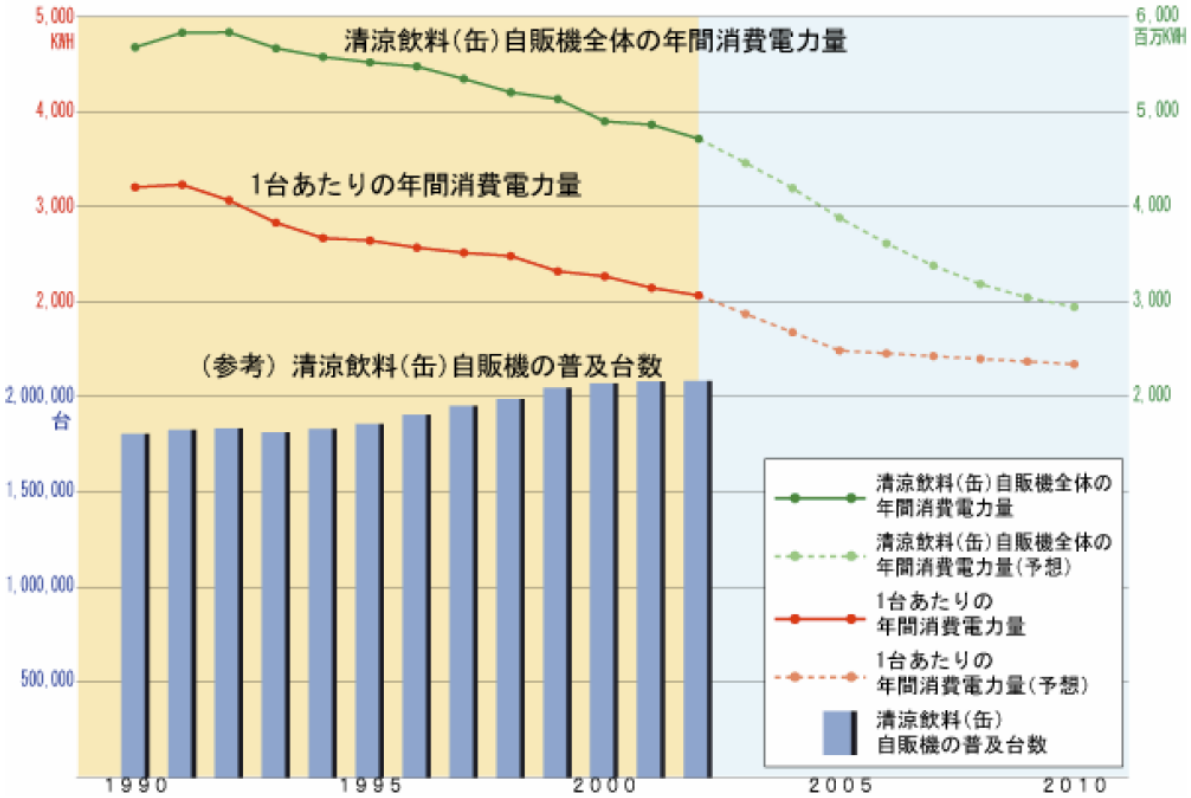
State University of New York at Buffalo
132 vending machines

Annual Savings: $20,948
Annual Energy Savings: 261,849 kWh

- The US vending machines market doubled within 7 years – a perfect rebound effect.

- What about Japan?

Total electricity consumption of the soft drink machines in Japan decreased as a consequence of improved energy efficiency (i.e., almost *no* rebound effect has been observed):

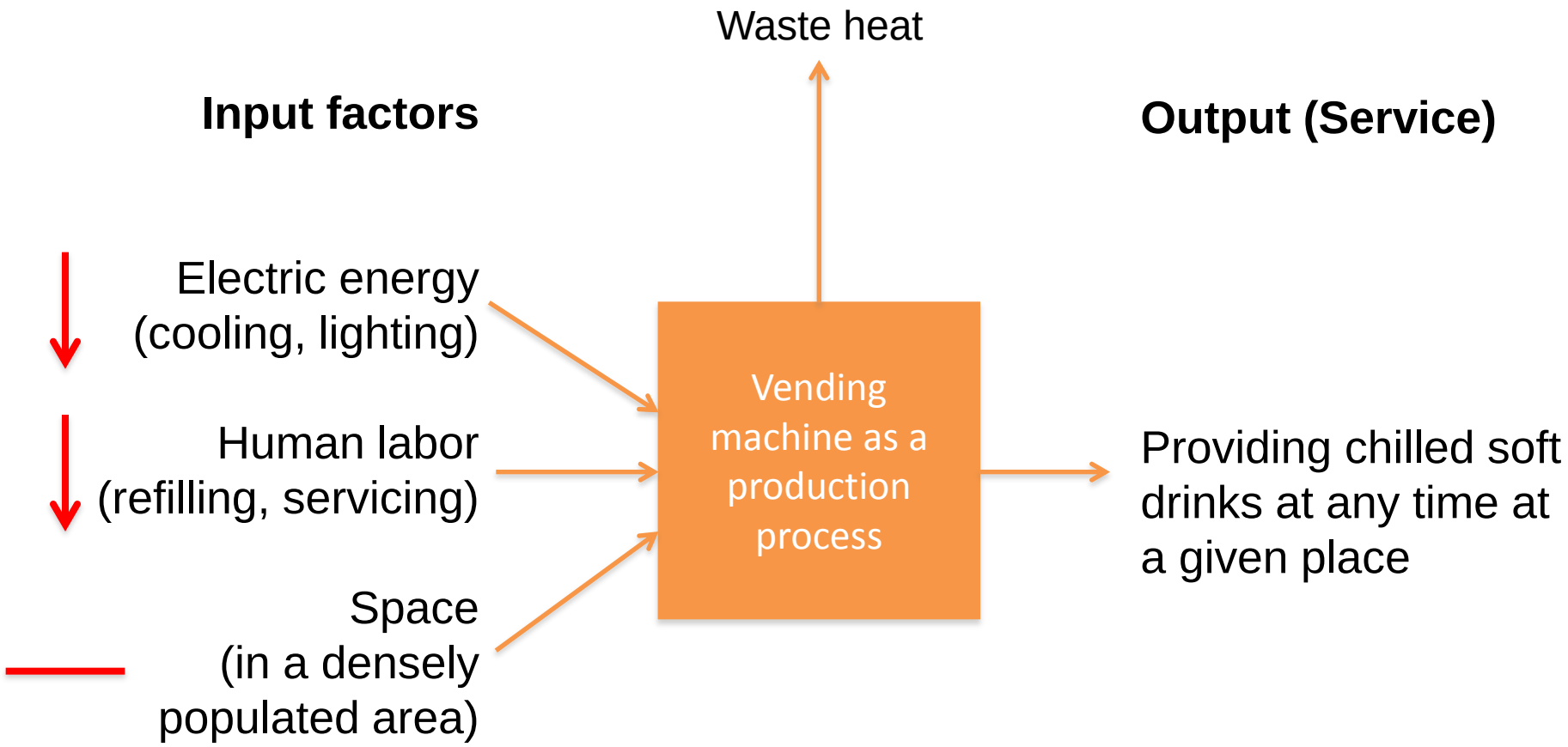


Development of Electricity Consumption of Canned Soft Drink Vending Machines from 1990 to 2010 in Japan

Blue bars: Number of installed machines in 1000
Red line: Electricity use per machine in kWH/yr
Green line: Total electricity consumption of the installed machines in GWh/yr

Source: Japanese Soft Drink Association

Potential explanation: space as a limiting factor



effect of making the machine smarter

Energy efficiency seems to provoke rebound effects if there is no factor that limits the system.

Limits can be given naturally or set "artificially" as in the "cap and trade" approach to emissions trading (known from national and international trading schemes).

Cap and trade can also be used as an **organization-internal instrument (see following slides).**

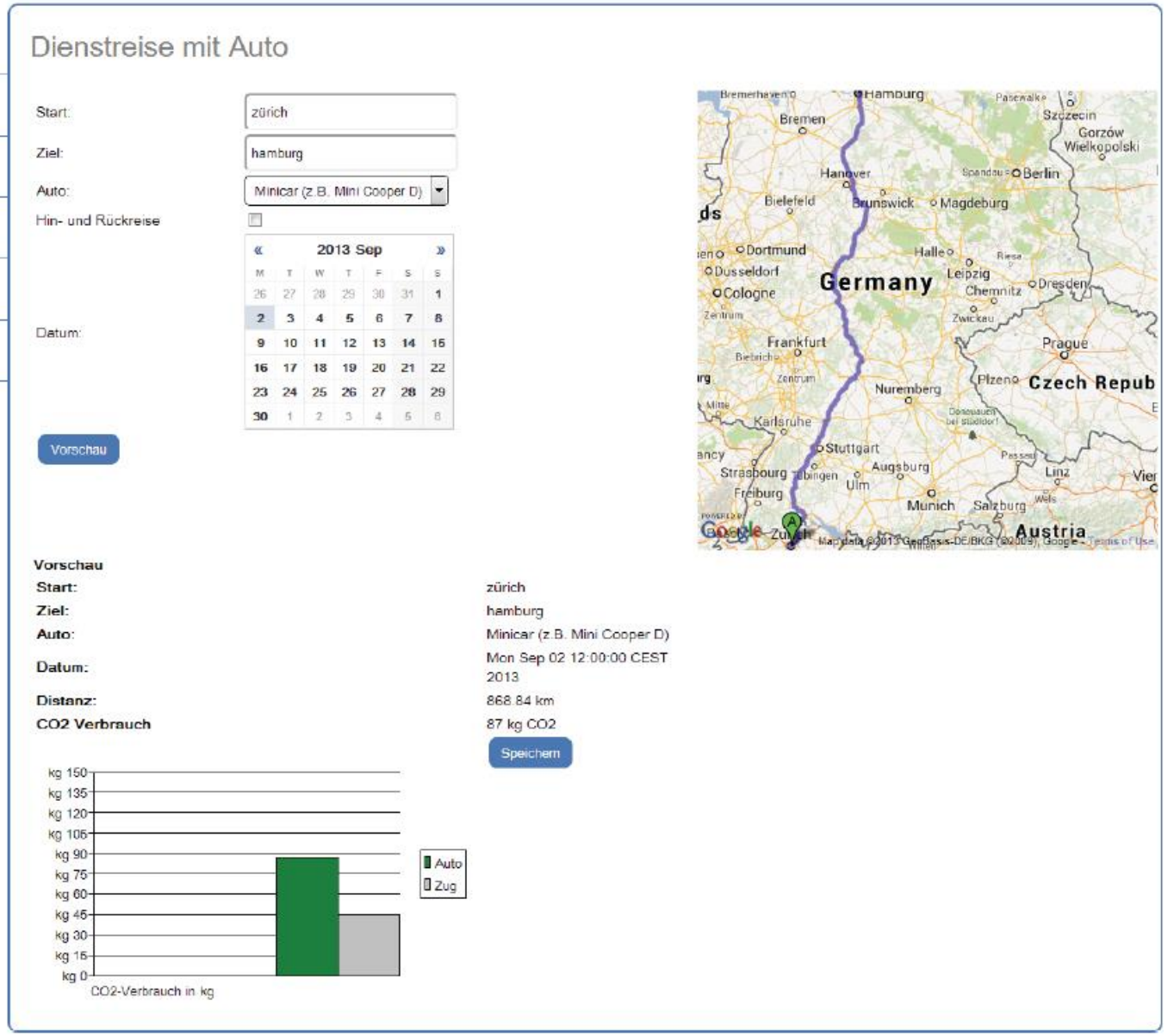
Example of organization-internal cap and trade:

- A university institute decides to reduce the CO2 emissions caused by the travel of their faculty
- They set a cap to 80% or 90% of last year's emission.
- Emission permits are equally distributed to the faculty members at the beginning of the year.
- There is an internal electronic market, in this case for "travel-related CO2 emission permits".
- Before travel, everyone must allocate the necessary number of permits to the trip.
- Who needs more available, must buy on the market; a price will emerge.

Planning a trip by car, system calculates route and emissions (green bar).

System suggests train to save emission permits (grey bar).

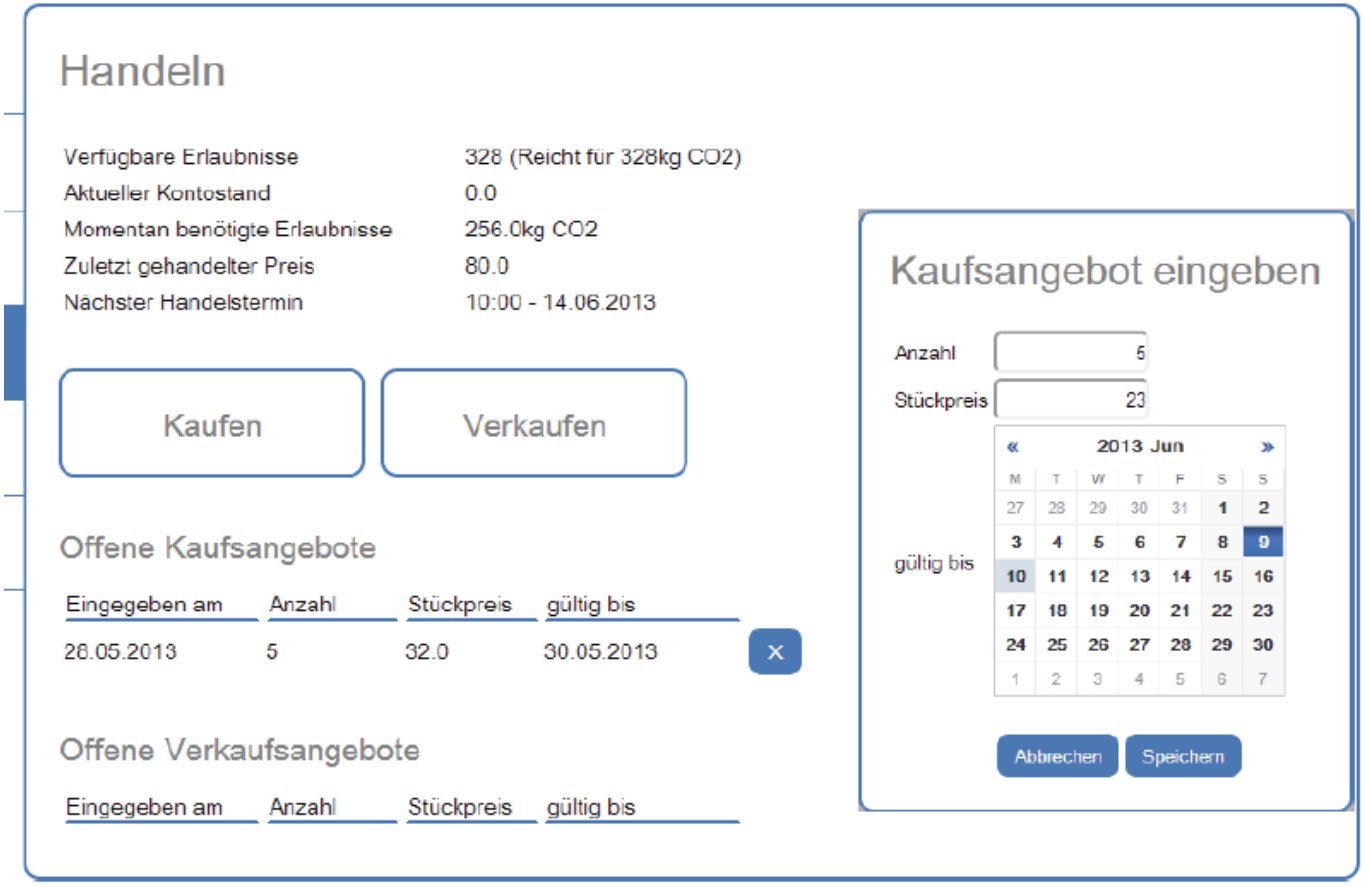
User interface in German



Placing a bid to buy or to sell an amount of permits at a max or min price, resp.

The bis has a period of validity that can be set.

User interface in German

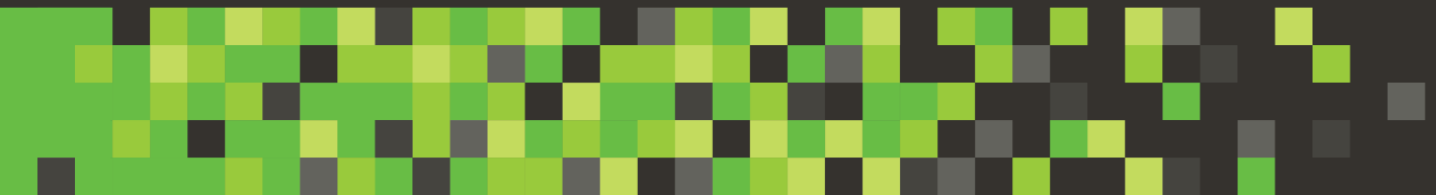


System developed by David Oertle and Stefan Badertscher at University of Zurich.

Conclusions: Decoupling

- The most essential contribution of ICT to sustainability is to support decoupling GDP from material extraction.
- The decoupling rate is lower than it could be due to rebound effects.
- Rebound effects can be controlled by caps, e.g., set by organization-internal cap and trade schemes.
- ICT solutions will support this and similar market-based instruments to make them efficiently applicable.

Thank you for your attention!



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