The personal CO₂ calculator: A modeling tool for Participatory Integrated Assessment methods

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Participatory Integrated Assessment (PIA) is an approach which aims at developing methods which allow to combine evaluations of experts and lay people in the field of Integrated Assessment. Thus, policy recommendations derived from PIA exercises are informed by scientific judgments and by valuations of “non-scientists”. For any PIA methodology the provision of insights, facts and figures about the policy problem at hand is crucial.

In this paper we describe a PIA methodology which combines the social science research instrument “focus group” with a specific computer information tool, the “Personal CO₂ Calculator” (PCC). The tool supports citizens in discussing and recommending measures on climate change policy. Based on our experiences, we plead for information instruments that are tuned to and assist concrete target groups with their specific interests. This helps that policy recommendations derived from PIA exercises are based on both scientific knowledge as well as citizens’ and stakeholders’ policy preferences.

Keywords: Integrated Assessment, participation, focus groups, modeling tools, climate change

1. Introduction

The need for new and creative approaches to tackle complex (global) problems, and the irreducible uncertainties attending them, is hardly denied. Complex problems are problems which cannot be described comprehensively and unequivocally because of irreducible uncertainties. It is not possible to give an objective, unique description of a complex problem [8].

One such complex problem is human induced climate change [4,28]. The sciences are challenged by complex problems at least on two levels: first, there is a general need for basic research, and second, there is a specific need for high-quality scientific policy advice. The growth of climate research and the foundation of the Intergovernmental Panel on Climate Change, for example, express and reflect these needs. On both levels, expert knowledge is the key product the sciences feed into political processes.

With regard to the second level, Integrated Assessment (IA) is one of the most advanced and promising avenues of policy-oriented research on complex (global) problems [14, 25,35,40]. Integrated Assessment can be defined as

“an interdisciplinary and participatory process of combining, interpreting and communicating knowledge from diverse scientific disciplines to allow a better understanding of complex phenomena. Integrated Assessment has two main characteristics: (i) it should contain added value compared to insights derived from disciplinary research, and (ii) it should provide decision makers (and society) with useful information” [34].

So far, the generation of Integrated Assessments has been performed as an expert task within the scientific system. The most important Integrated Assessment tools are highly sophisticated computer models (IA models), based on cause–effect chains encompassing the whole decision problem from pressures over impacts to response strategies. Most IA models deal with the global climate problem. Important examples are IMAGE, ICAM, and TARGETS. The most important IA model on a regional scale is RAINS (for an overview of IA models, see [5]).

IA modeling is increasingly recognized as a key tool for supporting environmental policy making [17,33,43], especially on the international scale. The experiences collected in the context of acid rain and climate change are encouraging [26]. However, politics cannot and should not be reduced to institutional negotiations. Modern policy analysis frames politics as an untidy, multi-leveled process [38]:

- (i) There is a multitude of actors like public and private institutions, individual citizens, and social movements [37].
- (ii) Factual information is only one of several resources that shapes politics. Political processes are often more

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driven by a “struggle over ideas” [39], than by “rational facts” associated with the concrete policy problem.

- (iii) Political representatives are generally faced with a portfolio of questions and problems. This demands priorities in the allocation of resources [11].

Against that background, a narrowly defined Integrated Assessment focusing on expert knowledge only has obvious boundaries [3]. Policy decision support should not only be informed by scientific competence but also by stakeholder interests and societal policy preferences.

In this paper we plead for an IA approach in which social stakeholders – citizens in our case – contribute their knowledge and policy preferences to the assessment of complex policy problems [36]. We will call such IA methodology a Participatory Integrated Assessment (PIA). In PIA, scientific insights are combined with citizens’ concerns and policy preferences. The methodology is based on an understanding of the political sphere in which citizens actively participate in the policy process, from agenda-setting to legislation [1], and on an understanding of complex policy problems as problems on which a plurality of legitimate perspectives exist [12,34,42]. This allows for and demands deliberation and conflict resolution.

The inclusion of citizens should take place in a collective, participatory mode. As we know from participatory research and practice, an inclusion of social stakeholders in policy problem-solving often increases the legitimization of subsequent decisions [1,7,29]. This is desirable and increasingly needed because the credibility of expert- and elite-based problem-solving is decreasing. Furthermore, trust in “traditional” democratic processes in the context of complex global problems is fading [16]. Instruments that allow for participation and that strengthen discursive politics [8,13], especially in such complex fields as climate change, are badly needed.

As a first step towards the design of PIA, we tuned the social science tool “focus group” to the needs of Integrated Assessment (we will call such redesigned focus groups “IA focus groups” [10]) and combined it with a computer tool aimed at stimulating group discussion on climate change.

For lay people, the topic of climate change is very abstract and only loosely rooted in their daily lives. It cannot be perceived by senses and the relevant time frames exceed average time horizons of personal concern. A key challenge of PIA in the field of climate change is to link the global issue to living-world experiences and categories of ordinary citizens. For such reason, the small computer tool called the “Personal CO₂ Calculator” (PCC) was developed. It provides information about selected areas of life and associated CO₂ emissions. CO₂ has been chosen due to its quantitative relevance and due to its ability to create effective and clear links from the abstract “emission problem” to down-to-earth aspects of personal lifestyles and living conditions. The calculator supports citizens in assessing personal and collective saving potentials, developing possible and desir-

able emission goals, and discussing implications of policy measures on their lives.

Before we introduce technical details of the PCC in section 3, and its use in section 4, we will describe in section 2 the focus group method and its adaptation to the IA context. In section 5 we will summarize key findings and expand on possible extensions and further applications of the software tool.

2. Focus groups

2.1. Focus groups as an instrument of social research

The “focus group” is a social research instrument [19, 23,24]. The method is oriented towards investigating and exploring qualitative characteristics of a problem, e.g., concerns about climate change. Focus groups do not produce representative quantitative data, but qualitative insights that enhance our understanding of how specific people or groups of people perceive and evaluate the topic under investigation.

The focus group is a tool which integrates characteristics of the focused interview [9,24] and of the group discussion. Thus, we can define focus groups as *topic-focused group discussions*, stimulated by an input and guided by a skilled moderating person. Topics of investigation can be the group itself (e.g., to study group dynamics) or a specific issue on which group opinions are gathered. Focus groups consist of half a dozen to a dozen people. Participants are selected with different sampling procedures (from simple random samples to convenience, purposive and quota samples), depending on topic and research goals. Groups generally meet once for about two hours.

Information on the topic at hand can be provided as general stimulus and/or as specific input by means of oral presentations (e.g., lectures), written documents (journal or scientific articles), and electronic media (e.g., computer models). The task to tune the information to the needs of a focus group should not be underestimated. In case the information does not meet the requirements of the group, the whole process can be heavily jeopardized. Thus, it is crucial that any information given to the group is accessible to all its members [31].

The moderation task requires professional skills. The moderating person should be able to handle different moderation techniques. The most appropriate role is the role of a convener that facilitates a discussion [9]. An important rule is not to switch between different roles (e.g., to the role of an expert or the role of a participant). This leads to confusion and uncontrolled framings of the process.

The output material of a focus group can be divided into two types: material “about the group”, like video tapes, minutes and transcripts, and material which is a “product of the group”, like collages or citizen reports. Both types of output are used for scientific analysis. The amount of material produced by a focus group has a great diversity and requires very systematic analysis.

Focus group research started in the field of political propaganda during World War II [21]. It is extensively used in market research [15]. Scientific applications have increased in the last ten years or so, especially in health research [18] and, most recently, in environmental risk research [6,20].

2.2. Focus groups in Integrated Assessment: An example

We developed a focus group methodology which tunes the standard format of the focus group to the requirements of IA. First, we used a panel format, i.e., groups meet several times. Second, the group stimulus is not an "event" but purposive information on the complex policy problem. Third, the groups produce written output (so-called "citizen reports") that documents the policy recommendations of the group.

In a pilot phase, a variety of sessions with different format and target groups were conducted: in ten one-shot (single session) groups information material and discussion guidelines were tested. In a three-shot panel we tested the procedure to produce a citizen report, and the concept of the PCC. In a second phase, we improved the methodology and introduced the PCC as an instrument. Four five-shot panels were conducted. One of these panels was linked to the "Local Agenda 21" process of Zürich in order to establish a real link to politics.

In this paper, we refer to experiences made with these four five-shot panels, conducted from September 1996 until April 1997.

The groups consisted of citizens that differed with respect to age, gender and professional background. A group encompassed 6–8 persons. This is a convenient size that guarantees lively discussions, a congenial atmosphere and adequate speaking time for the participants. The groups met in the evenings for about 2.5 h. The sessions took place in a weekly rhythm and at a neutral location. A small amount of reimbursement was given to the participants.

In the first session, participants "warmed up" with the topic. An important goal of the session was to build trust among the participants and with the organisers, the procedure, and the research at large. The second session was devoted to climate change as conceptualized in the sciences. Background knowledge about important processes and impacts was given to the group (fact sheets, in some groups a small simulation model). In the third session, the PCC was introduced in order to stimulate participants to reflect about personal routines and behavior that might contribute to climate change. In the fourth session, pros and cons of selected policy measures, documented on fact sheets, were discussed. In two groups, the topic of session four was introduced in the third session (technical reasons, only). In the last session, the citizen report was compiled, based on output of the previous sessions.

The PCC is based on the need to offer the participants a link between the abstract climate change topic and their living-world realities. We decided to focus on climate relevant emissions of everyday activities. This link allows

for discussing personal lifestyles as determinants of environmental pollution. This is a rather familiar framing of environmental problems [20]. The PCC does not claim to define or contain a typology of "lifestyles" or "ways of life". It simply calculates for the most important areas and activities of everyday life CO₂ emissions according to social, consumptive and technical parameters set by the user. The rationale of the tool is to stimulate discussion by giving information about CO₂-consumption patterns and to animate people to explore saving potentials.

3. The personal CO₂ calculator

3.1. A modeling tool for focus groups

The Personal CO₂ Calculator (PCC) was produced in autumn 1996 at the request of participants of focus groups that discussed climate policy. This demand-driven approach to modeling is an important part of our understanding of a "Participatory Integrated Assessment".

The PCC allows one to calculate the amount of CO₂ that is emitted to support a specific "lifestyle choice" (in the areas of "Nutrition", "Housing", "Mobility", "Private and Public Consumption") of a Swiss citizen.

The PCC is thus not an integrated assessment tool like other IA models, i.e., it does not address the whole chain of causes and effects of climate change and does not assess measures to mitigate or adapt to climate change. It is rather a tool to give citizens an idea of how their behavior is related to the problem and what could be done to reduce this impact in terms of their own behavior.

To be useful in a focus group setting the PCC has to fulfill several requirements besides being able to estimate personal CO₂ emissions.

First, it must be accessible to citizens. They should be able to interact directly with the tool for entering their own lifestyle choices. Therefore the calculator needs a graphical user interface with an easy structure and intuitively understandable lifestyle choices.

Second, it should not take too much time to estimate a CO₂ budget with the PCC. The length of a focus group session is limited, and participants do not like to work over a long time without getting results. A PCC run lasts about 15 min (without discussions).

Third, the calculator must give direct feedback when the user enters his or her personal information. This helps to assess the relative importance of one "lifestyle option" to the whole budget. As a discussion support tool, the calculator has to be highly interactive so that citizens can recalculate the budget during their discussion.

Finally, as a normative part, the PCC should allow to compare CO₂ budgets. Citizens should be able to compare their budget with average personal budgets of citizens living in other world regions. This feature is needed to stimulate discussions about equity issues.

3.2. Assessment of already available environmental-budget calculators

Computer-based tools to inform lay persons about environmental problems are available for many topics [27]. With the multimedia revolution and the increasing performance of personal computers, interactive and user-friendly multimedia software becomes easier to be developed and deployed than ever before. We examined two software products that are directed to the topic of personal CO₂ emissions:

- “Meine Persönliche CO₂-Bilanz” by Senatsverwaltung für Stadtentwicklung und Umweltschutz, Berlin;
- “Earth Aware Personal” by EnviroAccount Software, 605 Sunset Ct., Davis, California 95616.

Both products are targeted to lay persons and have a rich multimedia user interface. “Meine Persönliche CO₂-Bilanz” is very close to the PCC. It consists of many well-illustrated screens. The user can enter his or her lifestyle options in five areas of lifestyle activities. She gets many useful tips on how to reduce her personal CO₂ emissions. It takes about one hour to answer all the questions that are needed to calculate the budget. The tool lacks the ability to directly reflect the change in the total CO₂ amount by changing options. It is also not very transparent because one can only see a single option at a time on the screen.

While the many pictures on the screen and the information on how to reduce personal CO₂ emissions are good for educational purposes, they tend to make the tool unhandy for quick budget recalculations.

“Earth Aware Personal” is a software that allows to calculate the overall impact of a person’s lifestyle on the environment. It does not only assess CO₂ emissions but also energy, waste, livelihood and land use. The model scores environmental impact by giving impact and action points. Users are ranked on a scale from “Titan” (very low environmental impact) to “T. Rex” (massive environmental impact). It takes more than one hour to work through the software. For scenario and sensitivity analyses the same holds as for the tool “Meine Persönliche CO₂-Bilanz”. The user interface is written in English, which is quite a barrier for German-speaking citizens such as in the focus groups we conducted.

Both models do not rely on a generic concept, e.g., you can not easily adapt the data to a different country or change the language. The “Meine Persönliche CO₂-Bilanz” relies on data for Germany and “Earth Aware Personal” relies on U.S. data.

As both models lack a direct interactive budget recalculation, are not easily adaptable to Swiss data and are directed to a single user who has much time to play with the tool, we decided to produce a CO₂ calculator that is applicable in focus groups and more transparent in terms of the calculations.

3.3. Basic information about the CO₂ calculator

The PCC estimates the personal CO₂ budget based on the main CO₂-producing activities in the “lifestyle pattern” of a citizen. The citizen is seen as the only final consumer of goods and services. All activities to produce these goods and services, including associated emissions released outside Switzerland (grey emissions), are considered in the budget. The system thus has no geographical boundary concerning the source of emissions.

The calculator is based on a static representation of a CO₂ budget of Switzerland for the year 1992. In contrast to most national energy budgets, the PCC is not divided into economic sectors like “Industry”, “Households”, “Agriculture” and so on. The sectoral budget is reassigned to four areas of lifestyle activities (Nutrition, Housing, Mobility, Private Consumption) and to “Public Consumption”. Each area is composed of several “lifestyle choices”. The allocation of emissions to the options is a very hazardous data collection exercise. Greenpeace has produced a paper-based questionnaire for CO₂ emissions for Swiss citizens [2]. The background information in that questionnaire contains most of the data we needed to produce the PCC.

Figure 1 illustrates how the data for the average Swiss CO₂ budget were compiled and processed for the questionnaire. First, the data of the national energy statistics was compiled. Then, the amount of imported grey energy was estimated and added to the national energy statistics. Fi-

Figure 1. Comparison of the partitioning of total primary energy consumption in the extended national statistics and in the questionnaire.

nally, the energy was redistributed to the different areas of lifestyle activities of the questionnaire.

Based on the CO₂ intensities of the different energy sources the CO₂ emissions were calculated. The average personal CO₂ budget was then estimated by dividing the total emissions by the number of people living in Switzerland. The Swiss average is about 10 tons CO₂ per capita per year. This is more than twice the per capita world average (4 tons CO₂ per year). 20–30% of the emissions are produced outside Switzerland and do not show up in official national budgets. This budget is smaller than in many other industrialized countries. One reason for this is that 80% of the electricity supply is produced with nuclear power and water power.

To be able to calculate “personal” CO₂ budgets Greenpeace compiled information about the average lifestyle in each category and estimated how deviations might affect the total CO₂ budget.

It must be stated that these calculations produce only approximate results. It is not possible to exactly calculate the amount of imported grey energy and to exactly assign the emissions to specific “lifestyle categories”. The uncertainty is unequally distributed among the areas of lifestyle activities. The imported grey energy is about 30% of the total budget. If this amount is estimated with an error of about 50% (conservative estimation), then the error for the total budget is about 15% which is not too bad. Concerning the PCC, we are mainly interested in relative changes stemming from changes in the lifestyle. These relative changes are less affected by the uncertainties than the absolute numbers.

Therefore we do not use error bars in the PCC. When the PCC is introduced to the focus group participants we discuss the uncertainties and state that the calculator produces an approximate estimation and that relative changes are more reliable than absolute numbers.

3.4. Technical details of the PCC

As stated earlier, the PCC calculates a personal CO₂ budget based on the CO₂-producing activities in the lifestyle pattern of the user:

$$B_{\text{tot}} = \sum_i B_i. \quad (1)$$

The total budget B_{tot} is the sum of the budgets B_i in the four main areas of lifestyle activities:

- Nutrition (quantity, type, CO₂ intensity);
- Housing (house building, household size, heating, equipment);
- Mobility (automobile, public transportation, flights);
- Consumption – private (goods and services) and public (infrastructure).

These four areas were chosen because they are independent in terms of the calculation of the CO₂ budget. Lifestyle choices in the area “Mobility” do not directly affect CO₂

emissions in the area “Housing”. Secondly, the areas reflect the main aspects of a citizens’ lifestyle that have an influence on CO₂ emissions and that have a meaning for the citizens. Finally, none of the areas can be neglected in comparison with the others in order to calculate the budget.

Each area comprises a number of categories where the user can make individual choices:

$$B_i = \sum_j CO_{ijk}, \quad (2)$$

where CO_{ijk} refers to the CO₂ emissions when choosing option k of the j th category in the i th lifestyle area. In some categories the CO₂ emissions CO_{ijk} are a function of several options ($K_1, K_2, \dots, K_x$):

$$CO_{ijk} = f_{ij}(K_1, K_2, \dots, K_x). \quad (3)$$

The area “Housing”, for example, comprises house building/maintenance and heating/equipment. In the category house building/maintenance the user has to specify all information to characterize his individual choice such as house type and household size. This specifies the quantities required to calculate the CO₂ emissions for this category within the area of housing.

The functions $f_{ij}()$ are very simple and consist mainly of additions and multiplication of CO₂ intensities for different options. They can easily be implemented using a spread sheet program like MS ExcelTM.

Figure 2 displays the corresponding form on the screen where users enter information about their personal data. Based on this information the personal CO₂ budget is computed and displayed in a diagram. The CO₂ budget responds immediately to any changes made by the users. This helps the users to assess the effect of different aspects of their lifestyle on their total CO₂ budget. Alternatively to the CO₂ budget, an energy budget can be calculated and displayed.

3.5. Calculations with the PCC: An example

In this section we present some calculations that can be done with the PCC. As an example we focus on “Housing” with the two main categories “Housing construction and maintenance” and “Heating”.

The average amount of CO₂ emissions is around 10 tons per person and year. The categories “Housing construction ...” and “Heating” are responsible for about 2.5 tons.

The calculation of the CO₂ emissions in the “Housing construction and maintenance” area is presented in formula (4):

$$\begin{aligned} CO_{\text{Housing}} &= f(K_{\text{Area}}, K_{\text{Persons}}, K_{\text{Housetype}}) \\ &= \frac{K_{\text{Area}}}{K_{\text{Persons}}} K_{\text{Housetype}} e_{\text{Housing}} \mu_{\text{Housing}}; \end{aligned} \quad (4)$$

- K_{Area} : Housing space [m²],
- K_{Persons} : Persons living in the household [number],

Figure 2. The "User Interface" of the Excel version of the PCC. It is comprised of three frames. The navigation bar on the top (grey) lets the user choose which part of his personal lifestyle he wishes to edit. Here the user can also choose whether he wants to see a CO₂ or an energy budget. In the second frame the current CO₂ or energy balance is automatically updated and displayed as the user enters his lifestyle data (middle bar). This budget can be compared to the Swiss average budget (top bar) and to a target value (bottom bar) (see figure 4 for an explanation of the target value). Each area of lifestyle has its own color: Nutrition (green), Housing (brown), Mobility (blue), Consumption (grey). In the main frame (white) the questionnaire for the chosen lifestyle category is displayed.

- $K_{\text{Housetype}}$: Housetype [factor] (1: one family house = 1.5, 2: row house = 1.3, 3: apartment house = 1.0),
- e_{Housing} : Energy intensity of housing construction and maintenance = 70 kWh/a m²,
- μ_{Housing} : Average CO₂ intensity of the energy for housing construction and maintenance = 0.00022 tons CO₂/kWh.
- $K_{\text{Technology}}$: Technology used [number] (1: very efficient, 2: rather efficient, 3: average efficiency (ϕ CH), 4: bad efficiency),
- $K_{\text{Temperature}}$: Mean temperature of heated space in winter [°C] (18–22°C),
- e_{Heating} : Energy intensity of heating [kWh/a m²]. This factor is calculated by interpolating a table $K_{\text{Technology}}$ vs. $K_{\text{Temperature}}$. $e(1, 18^\circ\text{C}) = 65 \text{ kWh/a m}^2$; $e(4, 22^\circ\text{C}) = 210 \text{ kWh/a m}^2$.
- μ_{Heating} : Average CO₂ intensity of the energy for heating. Most Swiss houses are heated with oil. This leads to a CO₂ intensity 0.00026 tons CO₂/kWh. An additional feature would be the possibility to change the energy source for heating. We have implemented this option in the Internet version of the PCC.

For a two-person household with an average housing space of 80 m² in an apartment house CO₂ emissions yield to 0.62 tons per person and year.

Formula (5) calculates the CO₂ emissions produced by heating housing space:

$$CO_{\text{Heating}} = f(K_{\text{Area}}, K_{\text{Persons}}, K_{\text{Technology}}, K_{\text{Temperature}}) \\ = \frac{K_{\text{Area}}}{K_{\text{Persons}}} e(K_{\text{Technology}}, K_{\text{Temperature}}) \mu_{\text{Heating}}; \quad (5)$$

- K_{Area} : Housing space [m²],
- K_{Persons} : Persons living in the household [number],

By using the same values for K_{Area} and K_{Persons} , choosing an average technology and setting the room temperature

Figure 3. Two different calculations with the PCC. The upper diagram is calculated with Swiss average settings for all parameters except for choosing a very efficient heating technology. The lower diagram is calculated with Swiss average setting for all parameters except for "Persons in Household", which is set to 4 instead of 2.

Figure 4. The dialog to choose a target value to compare the personal budget to. When the user makes a choice, it is immediately reflected in the PCC as a separate bar that can be compared to the personal budget.

to 21°C yields CO₂ emissions of 1.87 tons per person and year.

Citizens may change any of the 5 parameters to test the effect of any technology or lifestyle change. Figure 3 shows two results. The upper part of the figure is calculated with the technological option $K_{\text{Technology}}$ changed from "3: average" to "1: very efficient". This reduces the overall per capita CO₂ emissions from 10 to 9 tons per year. The lower part of the figure is calculated by assuming a four-person household instead of a two-person household and keeping floor space constant. With this option, yearly per capita CO₂ emissions are below 8 tons.

This simple example illustrates how participants can experiment with the PCC and think about technology and lifestyle-driven emission patterns. A short excerpt from a focus group discussion about such emission options is presented in section 4.3.

3.6. Normative part of the PCC

The PCC contains a normative part that is intended to stimulate discussions about regional differences in CO₂ emissions, energy usage and equity. Therefore the personal budget may be compared to:

- the average budget of citizens in the same region (in our specific case this region corresponds to Switzerland),
- the budget of a citizen in another world region,
- the world average per capita CO₂ budget,
- or to a percentage value of the average Swiss or of the actual personal budget.

We intend to further include comparisons with a series of ideal types of lifestyle patterns.

Figure 4 shows the entry form where the user can choose a target value for comparison with the personal budget. The PCC contains data of CO₂ emissions for 11 world regions.

Figure 5. Yearly per capita CO₂ emissions in different world regions in descending order. This diagram is part of the background information the PCC is supplemented with. The current value of the personal balance and the chosen target value are displayed.

A diagram of all regional CO₂ budgets is also included in the PCC (see figure 5).

The PCC is supplemented with background information on anthropogenic climate change, lifestyle and CO₂ emissions.

3.7. Software implementation

The PCC is implemented as a workbook in MS ExcelTM. It relies on the generic concept of a spread sheet. Therefore the calculations are directly accessible to anyone interested. The user interface is based on Excel too. It is possible for an experienced computer user to change the user interface and the calculations to adapt the PCC to other countries. Research groups within the ULYSSES¹ project that use focus groups to discuss lifestyle and sustainability have adapted the PCC.

¹ Research groups in Canada (University of Vancouver), the USA (Carnegie Mellon University), Germany (Darmstadt University of Technology), Spain (Institut d'Estudis Socials Avancats – CSIC) and Italy (Joint Research Centre, ISIS, Ispra) [30] currently collect additional experiences with modified versions of the PCC. This will contribute to the task of developing new tools for participatory IA methodologies.

In addition to the Excel version, we are developing a version of the PCC for the World Wide Web. It can be used over the Internet with Netscape NavigatorTM 4.0. It is supplemented with a mouse-sensitive help-system and a multi-level navigation scheme that assists the users in finding their way through the program (see figure 6).

4. Preliminary experiences with the PCC in focus groups

4.1. The setting

A standard session with the PCC had the following structure: In the first part, participants were asked to exchange their experiences about environmentally relevant daily routines, and to debate the importance of individual behavior with regard to environmental relief. Discussions were generally guided along four topics: (i) Thinking about “lifestyles”, what this concept means to the participants, and (ii) how it (possibly) differs from and relates to consumption patterns; (iii) thinking about environmental behavior, how daily activities relate to environmental pollution, and

Figure 6. The "User Interface" of the Internet version of the PCC comprises five frames. The navigation bar on the left lets the user choose which part of his personal lifestyle he wishes to edit. In the top frame the current CO₂ or energy balance is automatically updated and displayed as the user enters his lifestyle data. In the main frame the questionnaire for the chosen part of the lifestyle is displayed. The bottom frame displays mouse sensitive information.

(iv) how changes in lifestyles might help to reduce negative ecological impacts.

After this introductory discussion, the concept of the PCC was explained. Whenever possible, the issues raised in the opening conversation were used to introduce the different areas of the PCC. This presentation did not consume more than 10–15 min.

In the second part, the group was split up into two small subgroups of 2–4 people. In each subgroup a laptop with the model was available. After a short introduction about the handling of the tool by the moderating person, participants could choose whether they wanted to use the model with or without assistance. Approximately half of the people wished to use the CO₂ calculator on their own. However, without some background service the proper and efficient operation of the model would not have been secured. In a first "run", each participant could feed the tool with his/her personal data. Then, the results were compared and discussed within the subgroup. In the following paragraphs, we will first give an overall impression and then illustrate with some dialogues, stemming from transcripts of the discussions, how the participants made use of the tool.

4.2. General findings

Most welcome was the fact that the model is very handy, i.e., it does not need long introductory explanations or long working sessions and it can be operated by the participants themselves. A sub-group of two to three people needs about half an hour to explore the model and to calculate budgets. The easy-to-handle graphical interface and the comprehensible choices allowed the users to feel at home with the calculator.

Another finding was that the tool can not be applied without appropriate background information. The moderating person should have some knowledge of the databases and the reliability of the results in order to help the participants judge the accuracy of the data.

The PCC strongly helped citizens to link the abstract topic of CO₂ emissions and climate change to their living-world realities. Firstly, it conveyed basic information about their current level of CO₂ production, including breakdown to different activities. Secondly, it allowed them to compare individual budgets within the group. Such comparisons triggered interesting discussions and insights.

Furthermore, links to climate change can be installed with the help of comparisons with national per capita aver-

age consumption or any externally set per capita emission target. Against such a background, the model stimulated participants to experiment with reduction potentials. Most users explored the whole range of options: technological changes (increases in energy efficiency), individual consumption reductions and personal changes in "lifestyle".

4.3. Reflection on personal consumption

In this example, two participants look at the results of P1² who has just fed into the computer the personal data. While P1 is especially surprised about impacts of the consumption of warm water and even thinks of having a shower instead of having a bath, P2 judges this as not very relevant:

P1: I am not on a much lower scale than you are. It seems that the proportions have changed, haven't they? (...) It is amazing. Yes, it really makes a great difference, I can hardly believe it. I really have to think about my behavior. I really have to start having showers. (...)

P2: But look, (overall) the consumption of warm water is not significant. (...)

Implicit, the dialogue points at a potential "danger" associated with the use of the PCC: The tool may stimulate feelings of "social control", i.e., the attitude to "justify" personal consumptions and lifestyles. It is a challenging task for the moderating person in this part of the focus group process to guarantee a cooperative atmosphere and to encourage people to say frankly how they live, also how luxurious they live. A variant on this is given in the next example where P1 and P2 are trying to gather environmentally positive examples and try to contrast them with – from their point of view – environmentally "less conscious" people:

M: So you have an impression of two great energy saving potentials, namely heating and traffic. (...)

P1: In principle, two people could live there and then heating would decrease by half.

M: Let us try that out now.

P1: Actually, there is no need for (a single person to have) a two-room flat. One could also live in a one-room flat.

M: If you do that, heating decreases substantially.

P1: Yes, that's tremendous.

P2: Amazing! (...)

As a reaction to this, P1 and P2 again think about their personal situation:

P2: Thank God we have such a well-insulated (house), (...) My thermostat mainly stands on zero. I do not need to heat. The people above and below heat and there is no need for me to do so!

P1: Well, sometimes this is also the case (in our house). The heating in the bedroom is often switched off. (...)

Next, they experimented with different room temperatures as another possible step towards a lifestyle change.

4.4. National energy/emission saving potentials

Here, the participants are discussing saving potentials of CO₂ emissions on a collective level. They generally judge (Swiss) per capita consumption as very high. Consequently, they identify rather large saving potentials:

M: Just give (your assessments) in percent (what is sensible for the general public). What is possible for a single person, is not necessarily sensible for the public.

P1: Yes, exactly.

P2: ... with the refrigerator and all those cooling gadgets (...) we could probably save 50%.

P1: Yes, I would agree. There is a saving potential of 50% concerning nutrition, I would say. Yes, 50%, I would say that. (...)

P2: We can do nearly nothing in the flat.

P1: No, but theoretically we could do something. OK, this depends on the whole population. Naturally, we also have many single households.

P2: Yes, sometimes even more singles (than others). And the living situation. One could indicate 30% when considering heating.

P1: Yes, there we could perhaps and probably also with warm water as well as electricity. There is a huge potential with the car, one could do much if one liked to, that is the topic it is about.

These are very rough and partly insufficiently reflected assessments and extrapolations. However, running through the model in such a mode helps to construct first estimates that can be adapted to new insights and arguments during the discussions. Furthermore, the bottom-up approach seems to increase the participants' trust in their assessments, as the following excerpt illustrates:

M: It is interesting (...) according to the CO₂ calculator and your personal assessments the saving potentials (of CO₂ emissions) you now support are much larger than what you supported in the policy discussion about goals and measures. (...)

P1: I mean, we have simulated this with the computer; we could clearly see what is plausible.

P2: It could be expressed like this: Political guidelines (...) are much more realistic if they are done on the basis of your personal data. (...)

Any simple conclusion derived from aggregating changes of individual lifestyles to potential impacts on the social level is problematic. The risk in doing so was extensively discussed in the groups. An example of such a discussion is the following dialogue on diet practices:

² P1, P2, P3, ... stand for participants, M is the moderating person. Expressions in parentheses are added by the authors for better understanding. All dialogues come from focus groups conducted between September 1996 and April 1997 in Zürich, Switzerland.

P1: But when we briefly come back to nutrition: Personally, I do not understand the point about “vegetarianism”. I find this (data) really stupid, (...) how fast CO₂ emissions are decreasing (when switching from a meat to a vegetarian diet). I mean, if we do not eat meat any longer, then we would need anything else (that will produce emissions).

P2: Protein too

P1: Then we would need areas for agriculture where we could plant maize, pumpkin, and tomatoes, and cabbage ... But there aren't more areas for agriculture available – unless we deforest again (...), and moreover, we would have to increase production (...); but we can only produce more by using chemical fertilizer. Well, these graphics indeed raise some heavy questions! It looks beautiful, but how is it feasible?

5. Conclusions and outlook

The experiences collected with the PCC in our focus groups showed that it is an interesting tool for discussion support. This is mainly due to the following features of the PCC:

- It has an easy-to-handle graphical interface;
- Calculations and choices related to living-world realities were useful information for citizens in the conducted focus groups;
- It does not take too much time to get first results;
- The PCC gives direct feedback when the user enters his or her personal information and visualizes the recalculated budget;
- The PCC contains normative information that allows to compare CO₂ budgets.

The positive experiences suggest to think about possible extensions and further applications of such tools.

Concerning possible extensions, the PCC could be extended to an overall environmental impact calculator that accounts for more than just CO₂ and energy. One option is to add further greenhouse gases to the PCC. CO₂ contributes by about 60% of the human induced radiative forcing of the climate system. Including other gases like methane could help people to better assess their overall impact on climate.

Another possibility would be to add an evaluation tool where the users can make a subjective assessment about which behavioral change is the most “cost–benefit” efficient in order to reduce CO₂ emissions by a certain amount.

A much more far-reaching extension might be to develop and design the models within focus groups themselves. A number of experiments show some interesting results towards this direction [22,41] which could become another approach of PIA.

Concerning further applications of such computer tools: the principle to use interactive computer models for evaluating the effects of individual choice can be applied to other

areas of decision making. The typical questions which can be tackled with this approach involve the computation of target variables such as budgets of resources (e.g., energy), emissions (e.g., CO₂), and costs (e.g., current prices). In case of more than one target variable one can explore trade-offs for single options. The target variables are computed based on the choice made for a number of independent activities. In case of the PCC we have currently implemented the two target variables energy and CO₂.

This approach could be used in regional planning where the options of relevant regional actors might involve the sustainable use of a resource (e.g., water) or the reduction of budgets of pollutants (e.g., copper). Another interesting area could be life cycle analysis (LCA). In LCA one collects many data which might be rendered more useful for decision making when they are available in interactive form where the effect of single choices can be tested. Such models could be useful for individuals that assess the effects of their personal choice as much as for round tables (focus groups) that debate options for future actions.

Currently, we are developing other computer tools for focus group applications in the context of PIA. An information system about regional climate change impacts is almost finished. It is a hierarchically organized multimedia encyclopedia where users can browse through a wealth of information to assess possible climate change impacts and the uncertainties about these impacts. Another tool we are developing is an information system about options to react to the climate change challenge on a regional level. The vision of a low-energy society can be explored and assessed in this model. Both tools are implemented for the WWW (World Wide Web) and we are currently pretesting them in focus groups.

With the spread of the WWW in the educational sector, Internet-based versions of such computer tools could easily be used in schools and at home. Focus groups can be used as a controlled testing environment for Internet versions of such educational tools.

We are convinced that special focus group oriented software tools like the personal CO₂ calculator will help to develop new and improve existing Participatory Integrated Assessment methodologies.

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Software availability

Both versions of the PCC are freeware. Please contact Christoph Schlumpf to get the software.

Excel version: You need MS ExcelTM 5.0 on a Macintosh or MS ExcelTM 7.0 on a WindowsTM system in order to run the PCC.

Internet version: You need Netscape NavigatorTM 4.0 in order to run the PCC. Use the following URL: <http://clear.eawag.ch/>.

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