OPPORTUNITIES THROUGH THE COMBINATION OF CLIMATE PROTECTION AND POVERTY REDUCTION BY OPEN SOURCE APPROPRIATE TECHNOLOGY (OSAT)

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OUTLINE

Eight proposals for overcoming poverty in developing countries by Appropriate Open Source Technology (OSAT) and horticulture, using income from voluntary compensation of GHG emissions

COMBINING CLIMATE PROTECTION AND POVERTY REDUCTION

OPPORTUNITIES THROUGH OPEN SOURCE APPROPRIATE TECHNOLOGIES[1]

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[1] The book is based on 20 years of collaboration between the authors in the field of solar technologies and on three publications of D. Seifert in the magazine "SONNENENERGIE", Deutsche Gesellschaft für Sonnenenergie e.V. (German Association for Solar Energy), 3/2017, 1/2019, 3/2019

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SUMMARY

The main aim of this book is to discuss the great opportunities that arise between Open Source Appropriate Technology (OSAT) for households in developing countries and global cooperation to reduce greenhouse gas emissions. The potential for saving CO_2 emissions by equipping poor households with sustainable technologies and overcome the firewood crisis is about 1 billion tonnes CO_2 per year.

The proposals focus on Innovation Institutes and on projects for households, small businesses and schools in developing countries. Thanks to OSAT trees no longer need to be cut down for fuelwood or charcoal. Through OSAT and garden settlements, millions of jobs can be created. Garden culture appears as an inspiring, groundbreaking innovation that offers solutions for global challenges.

The scale of the task can be estimated by assuming that 200 million households in developing countries need a transition to OSAT household energy. An installation in the order of 1 kW output per home results in a total of about 200 GW. This corresponds to the capacity of approx. 200 nuclear power plants.

The required jobs can be financed if they focus on appropriate technology and horticulture, because the effort is only a few percent or per thousand compared to capital intensive industrial jobs.

Financing through the compensation (offsetting) of greenhouse gas emissions can make a decisive contribution to meet the challenges of climate change and misery of developing countries. The Paris Climate Agreement created a suitable framework to combine climate protection and overcome the lack of prospects.

1. OPEN SOURCE APPROPRIATE TECHNOLOGY (OSAT)

1.1 Technology freely accessible and appropriate

Almost the entire practical knowledge, which we use, is freely available, i.e., not reserved by patents. Also, the rights are expired for most of the more than 100 million patent documents, from the 19th century to the present, which the European Patent Office has published on the internet in excellent structured form. Further Information about Appropriate Technology (AT) is available on free portals on the internet.

Photo 1.1: Cooking of porridge on a traditional charcoal brazier in Lusaka / Zambia
see chapter 3.1

For solving actual technical problems in developing countries, the problem is less that knowledge is missing, but that knowledge for those who need it, is hardly known or inaccessible and that often insuperable obstacles hinder the deployment of knowledge.

There is a possibility for people caught in the poverty trap to escape it and attain a life of dignity, but not with inappropriate technologies. Continuing as usual could only be realized if humanity would have additional earth globes in reserve. There is a lack of opportunities in developing countries to raise and deploy the existing helpful knowledge about Appropriate Technology. In no case should this minder the manifold initiatives organized by dedicated persons and external helpers to overcome poverty and helplessness, but instead should point out the opportunities offered by worldwide open cooperation for solutions of pressing tasks.

In principle, abilities and experiences of the many participants shall be included through open exchange in the development process.

1.2 Definition and Criteria of Open Source Appropriate Technology (OSAT)

"OSAT is made up of technologies that are easily and economically utilized from readily available resources by local communities to meet their needs and must meet the boundary conditions set by environmental, cultural, economic, and educational resource constraint of the local community." [4]

In his famous book "Small is Beautiful - A Study of Economics as if People Mattered" E.F. Schumacher writes: *"Ever bigger machines, entailing ever bigger concentrations of economic power and exerting ever greater violence against the environment, do not represent progress: they are a denial of wisdom. Wisdom demands a new orientation of science and technology towards the organic, the gentle, the non-violent, the elegant and beautiful."*[5]

The great natural scientist and politician Benjamin Franklin wrote in his memoirs about his personal motivation for the open source principle when he invented the "Franklin Stove": *„That as we enjoy great Advantages from the Inventions of others, we should be glad of an Opportunity to serve others by any Invention of ours, and this we should do freely and generously."*[6]

Criteria for appropriate, sustainable technologies:

- They improve the living conditions of the population;
- use only renewable resources (renewable materials, renewable energy) and, if any, only totally recyclable non-renewable resources;
- do not cause danger when operated under normal conditions; do not cause major danger in case of faulty operation;
- operate as independently as possible;
- are easy to use; are fault tolerant, even if operated under sub-optimal conditions;
- have a long service life and can be repaired easily at low cost;
- can be adapted to local conditions and can be developed iteratively if required;
- they are beautiful.

1.3 Application and Dissemination of OSAT

Pointedly formulated, Africa could be a paradise. However, it squanders its resources and destroys its habitats if it doesn't turn to sustainable ways. Establishment of institutes for sustainable development is necessary for the improvement of living conditions. These could be named "African

[4] J. M. Pearce: The Case for Open Source Appropriate Technology. Springer link to open access
See also: C. Sinclair: Chapter "Open-Source Humanitarian Design" in: WorldChanging – A User's Guide for the 21st Century. Abrams, New York

[5] E.F. Schumacher: Small is Beautiful, Chapter 2, Peace and Permanence. Vintage Classics, London. First published in 1973 by Blond & Briggs Ltd.

[6] https://www.ushistory.org/franklin/science/stove.htm (download 21.09.2022)

Research and Technology Institutes for Sustainability (ARTIS)”[7]. They can be crucial to establish the urgently needed millions of valuable and sustainable jobs.
These institutions should be bound and dedicated only for the common good and its work be completely transparent to pave ways of prosperity for the whole African population. They should strengthen the local population in their abilities and their responsibilities. The costs per OSAT-workplace would be low in comparison to high-tech workplaces in the industry.

1.4 OSAT Workshops and Scale of Tasks

OSAT is not supposed to be a laborious, ugly, short-lived "poor-people-technology", but pleasing developments. With an excellent holistic concept, the Innovation Institutes could demonstrate the great challenges and contribute significantly to their solution.

A wealth of examples of freely accessible, appropriate technology has been tested. The solutions can be further adapted to special requirements. Local jobs are created, and on-the-spot expertise enables permanent care if permanent sponsorship (in particular Innovation Institutes, see chapter 2 is provided (Photos 1.2, 1.3, and 2.1).

Photo 1.2: Solar cooker project SOLIN, Bolivia.
(by courtesy of J.A. Garrido Vázquez, Madrid)

Photo 1.3: Solar Lamp Projekt Tansania. (by courtesy of S. Popp, Freilassing)

As OSAT is not a matter of large technical plants, but primarily of decentralized appliances, there could be a misleading opinion about the size of the task. It should be considered that e.g. the power supply for 200 million households with a net power of 1 kW each, with adapted, sustainable technology is an installation of 200 GW, corresponding to the capacity of about 200 nuclear power plants - however with very low cost, without the danger of hazards and without problems of supply and disposal.

2. Urgent Need of Innovation Institutes

2.1 Tasks and Goals of the Proposed Innovation Institutes

For fundamental improvement of the living conditions in developing counties, creation of Innovation Institutes for Sustainable Development is necessary. These Institutes should focus on solutions to meet the needs of ordinary households who have been neglected in our high-tech-oriented world for decades.

A key objective of the Innovation Institutes should be the development and dissemination of Open-Source Appropriate Technology (OSAT) and Garden Culture to overcome extreme poverty and lack of

[7] D. Seifert: Traditional Charcoal in Africa and Need of African Institutes. http://solarcooking.org/seifert (June 2016)

perspectives. This facilitates to find and deploy appropriate solutions through worldwide cooperation, avoiding undesirable developments and skipping unnecessary steps. Their realization is inexpensive and affordable, because the effort demanded is much smaller than the solutions proposed by capital-intensive industries.

The size of the task requires an answer that goes far beyond the existing institutional capacity. Therefore, globally networking Innovation Institutes should be created, which serve the implementation of the UN Sustainable Development Goals (SDGs). As the proposed Innovation Institutes are independent of commercial interests and committed only to the common good, they should enjoy the highest esteem, striving to be the best driver of a transition to sustainable practices for all. The Innovation Institutes are directed at the UN Sustainability Development Goals and to the commitments against climate change. They should create millions of permanent jobs of great diversity, in the field of training, planning, consulting and in the practical implementation.

The poorest are often the least informed about opportunities such as the cultivation of vegetables, fruits and mushrooms; for the preservation of foodstuffs (according to FAO the post-harvest losses are often 30% to 50% of the production); the provision of electricity, heat; drinking water; for hygiene and health care; and for the water regulation e.g. by small dams and for drip irrigation.

2.2 Proposal: African Research and Technology Institutes for Sustainability (ARTIS)

Not only are the challenges immense, but also the vast opportunities. The urgently needed sustainable development requires millions of valuable and permanent jobs offered by apprenticeships and employment in the corresponding local production sites.

The institutions should serve the common good. Their work is completely transparent with the aim of creating prosperity for all. There is no lack of potential, but there are no institutions to implement it. These institutions must strengthen the indigenous population in their skills and tasks. The urgently needed worldwide cooperation in solving the great challenges is peace-keeping and peace-promoting.

The point is to find lasting solutions for local and regional problems. Appropriate technologies are needed and available, but often unknown. The proposed “African Research and Technology Institutes for Sustainability” can remedy this deficiency. Access to energy and its advantageous use are crucial for overcoming poverty. The current exploitation of the tree population for charcoal production is a danger for the African continent and there are opportunities to avoid a collapse at high level.

An urgent objective is to liberate people from the poverty trap. This poverty trap has many forms. Poverty can be self-reinforcing. But it can be overcome. We can compare two scenarios:

Scenario 1:
Imagine young people in a country in the South of Sahara waiting at a public place for a job that gives them an income for that day, and with which they could support their family. But for most of them this waiting is in vain; they have no training and there are no jobs. They are coming home hungry and angry. They are exposed to the temptation that they are recruited by a terrorist organization, and learn how to use violence. But there are alternatives.

Scenario 2:
Young people go in the morning in a local branch of the African Research and Technology Institutes for Sustainability (ARTIS). There they have a variety of chances, and the community

kitchen ensures that no one is hungry. The services of the Institute should include vocational training, as well as assisting in the creation of sustainable jobs. The variety of offerings allows young people to find appropriate education and employment. The creation of these institutions was neglected in the past decades, but the task is urgent. ARTIS can leverage to escape from the poverty trap.

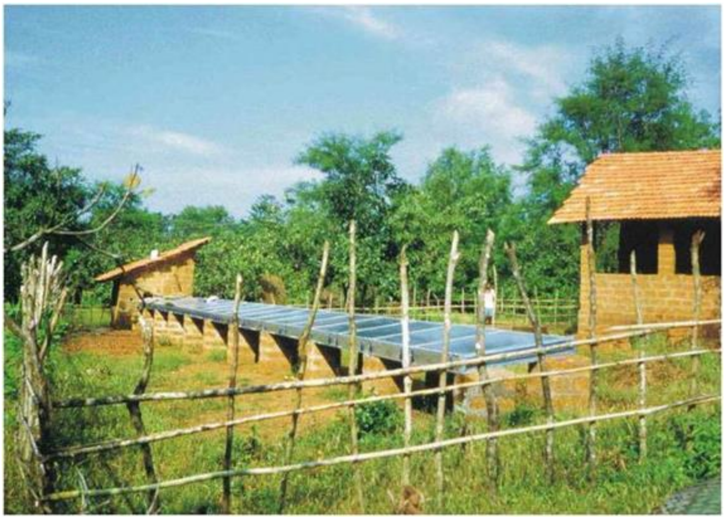
These notes highlight opportunities to overcome the lack of perspectives, especially among young people. When we consider the number of people who want to escape from misery in their homeland, we recognize that efforts of a completely different dimension than ever before are needed for the necessary transition towards sustainable development.

Opportunities exist to make use of the human and natural resources. However, instead of appreciating these opportunities, the African continent is losing its entrepreneurial population group, is being depleted and used as dumping ground for waste from industrial countries. African countries hardly do their own research and development to take care ordinary household needs. There is a lack of prospects and encouragement.

2.3 Models: University Institutes

In organizing the Innovation Institutes, university institutes can serve as a model and basis. In his speech[8] on the occasion of the 150th anniversary of the Technical University Munich, its President, Prof. Wolfgang Herrmann, said on April 12, 2018: *"As an urgent task for the future, I deliberately call the African continent, which deserves the attention of a leading technical university, more than in the past."* He then listed the "great challenges to society": Health and Nutrition · Environment, Climate and Energy · Natural Resources · Infrastructure and Mobility · Information and Communication**.** (Translation from German). The institutions might be organized like university institutes, with permanent staff and part-time employees. The facilities would include robust IT resources as well as laboratories, workshops and outdoor installations (example see photo 2.1). Funding could partly come from means to adapt to climate change.

Photo 2.1: Tunnel dryer for drying food with solar energy developed at the Technical University of Munich (German-Indian Solar Drying Project)
Source: courtesy Dr.-Ing. J. Blumenberg, Technical University Munich (TUM), Institute of Thermodynamics

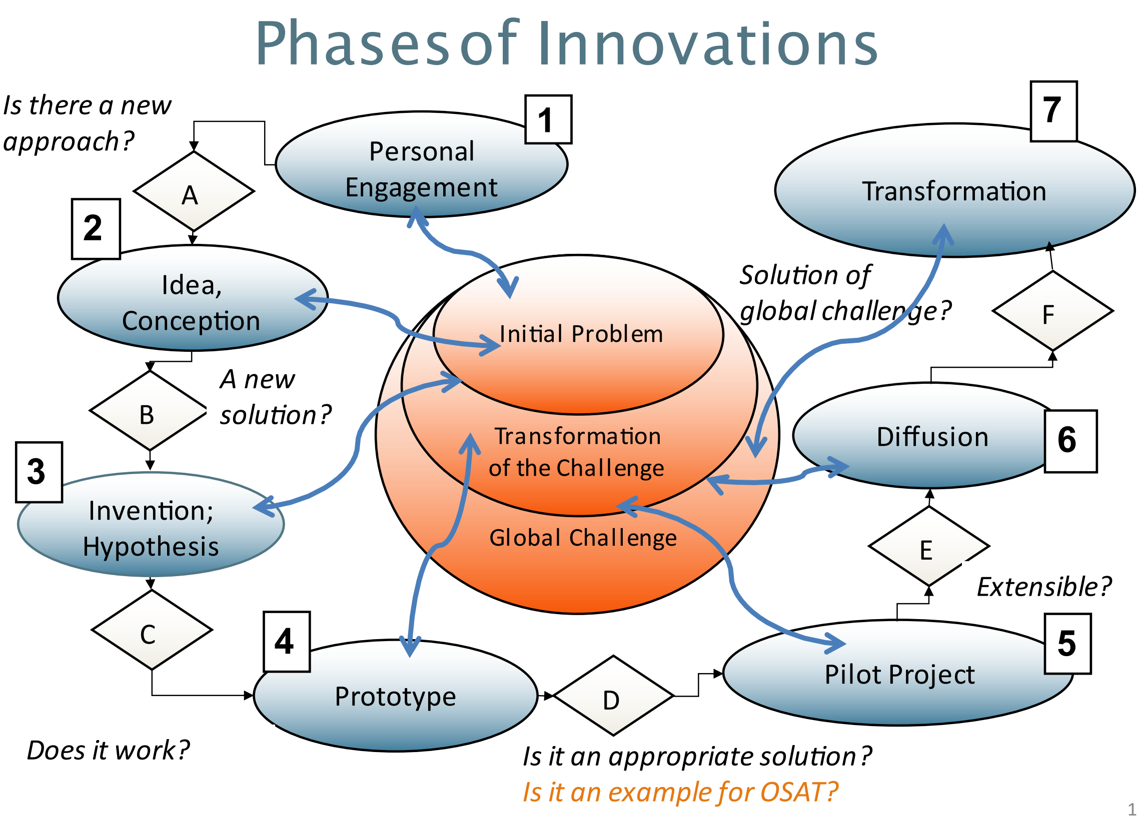


[8] W.A. Herrmann: 150 Jahre TUM. Innovation seit 1868. TUMcampus - Das Magazin der Technischen Universität München, 2/2018, p. 12-13

2.4 Innovation institutes for putting opportunities into practice

There is an incredible wealth of unused opportunities to overcome poverty in Africa. With appropriate institutes, the Sustainable Development Goals can be achieved. The African continent offers ideal conditions for the use of the solar energy, also to generate income. The European Patent Office[9] search provide free access to more than 100 million of patent documents online. It is a documentation beginning in the 19th century. Patent protection period is limited to maximum 20 years. A wealth of knowledge is freely available. From the patent documentation a great deal of information would be helpful for sustainable development if there is trained staff to benefit from these possibilities.

The graphic "Phases of Innovations" is intended to illustrate that the innovation process takes place in phases; at the phase transitions there is always the danger of failure, even with helpful, desirable developments. The graphic should also show that as the innovation process progresses, the tasks adapt and transform.



The Innovation Institutes should make use of all communication channels to foster education, skills and awareness. By employing the technologies developed resp. promoted by these institutes, millions of jobs can be created, transforming poor, suffering districts into prosperous domains. Individual local initiative should also be strengthened. Special emphasis should be placed on the development and dissemination of Open Source Appropriate Technologies, which can form a basis of the necessary worldwide technology transfer.

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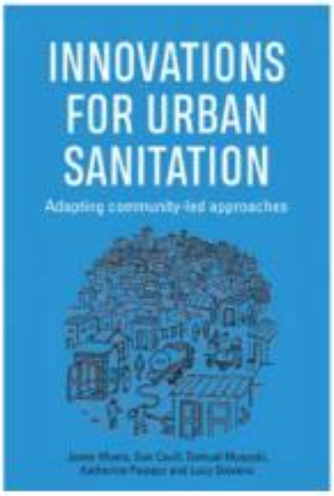
[9] http://www.espacenet.com



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As the specialist publishing arm of a global change-making organisation, we partner with the brightest minds to publish the latest development perspectives. We put affordable knowledge into the hands of people who need it most, whatever their location, in a language and format that suits them best. Rooted in hands on community development experience, we innovate and respond to what change-makers need - from practical 'how to' manuals to academic texts and journals; online, in print and open access formats. We put ingenious ideas to work so people in poverty can change their world. We all share the planet so let's share the answers. Find out more about us at practicalactionpublishing.com"

Photo 2.2 shows a course at the Center for Rural Technology, Nepal, an exemplary non-governmental organization (NGO).

Photo 2.2: Solar cooker course of Center of Rural Technology Nepal (CRT/N), see S. Shrestha: "Use of Solar Parabolic Cooker (SK14) in Nepal".

[10] www.practicalactionpublishing.com/Open-Access

3. PROPOSALS FOR ESCAPE FROM POVERTY TRAPS

Photo 3.1: Traditional fireplace in Nepal. Courtesy of K. Schulte, Rotary Sweden, SK14-project Bamti Bhandar)

3.1 Household energy supply with Open Source Appropriate Technology (OSAT)

"2.7 billion people cook and heat with energy from biomass, i. e. wood, charcoal, dung or agricultural waste. In most African countries, around 90 percent of households cover their daily energy needs with biomass. In rural areas, biomass is usually the only available source of energy. Cooking at traditional fireplaces leads to extreme smoke pollution due to inefficient combustion. Women and children in particular therefore suffer from respiratory diseases. Every year, more than 1.5 million people die as a result. In addition, deforestation leads to erosion and desertification of entire regions and fuel becomes scarce."[11]

As a rough estimate, we can assume that the 2.7 billion people cited in the quote live in households averaging 9 people. Then there are 300 million medium-sized households. For the overview calculations in this book (as a low estimate), 200 million households are expected for which a transition to OSAT is obvious.

Quotation from "The Encyclopedia of World Problems & Human Potential"[12]: *"Problem Shortage of firewood"*
"Almost 40% of the world population relies on firewood and charcoal as a source of energy for cooking and heating. In 1979 fuelwood consumption in developing countries (excluding China) was 1,300 million cubic metres, already 100 million cubic metre short of requirements; an estimated 250 million people live in areas of fuelwood shortage. 1,100 million rarely have enough fuel to cook their meals. By the year 2000 potential demand, at present per capita levels, rises to 2,400 million cubic metres, but actual needs to satisfy minimum requirements would reach 2,600 million cubic metres. There is some parallel with the gap between demand for food and nutritional requirements. Because of the shrinking of the resource base, fuelwood production may be only 1,500 million cubic metres - 1,100 million cubic metres short of requirements. As a result, some 3,000 million people would face acute fuelwood shortages by the end of the century, with the result that many poor people will not be able to cook their food adequately. This can have serous nutritional and health consequences. The digestibility of food will decrease and the incidence of parasites ingested with insufficiently-cooked meat will rise; there are already reports of this happening."

An example of a transition from a poor technique to an appropriate solution is the replacement of the traditional laborious open fire (e. g. Photo 3.1) or charcoal braziers (Photo 1.1) through OSAT. The annual fuel wood consumption per household of more than 4000 kg (open fire) resp. more than 8000 kg (charcoal brazier) can be reduced to about 400 kg per year by using an efficient firewood stove, thermos and solar energy (see Annex A). No tree has to be felled; short rotation plantations are sufficient.

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[11] From GIZ-article "Poverty-oriented basic energy supply" https://www.giz.de/expertise/html/60161.html; download 12.12.2022, 15:00

[12] http://encyclopedia.uia.org/en/problem/shortage-firewood; download 18.07.2022, 9:45

The Ben-stove[13] is used in this book as an example of a wood stove that meets the OSAT criteria (s. 4.2). A large number of firewood stoves are known[14], the suitability of which should be checked by the Innovation Institutes in the respective environment.

The use of the thermos technique[15] e. g. for cooking dry beans (a staple food in many regions) is a little-known opportunity; it can save several hours of active cooking time per meal.

The versatile SK parabolic solar cooker[16] is suitable also for applications where the three-stone fire can hardly be used, e. g. when baking and preserving food. On a sunny day, the solar cooker can boil about 40 liters of water. It can therefore meet the "suppressed demand" and avoid the rebound effect. Photo 3.2 shows a project for smoke-free villages with the combination of household biogas plants and parabolic solar cookers in India.

Photo 3.2: Smoke-free village in India; Courtesy of D. Gadhia and J. Reddy, NEDCAP

In Africa, a "Billion-Dollar-Business" with charcoal has been established, which sacrifices the trees of the continent within one generation if no turning point occurs soon. A tree, perhaps a hundred years old, is logged on one day and after a few days is charred and then in a few hours the charcoal is burnt on primitive braziers (Photo 1.1) in urban households.

3.2 Saving CO_2 emission through transition to OSAT

The worldwide destruction of tree population for cooking purposes causes greenhouse gas emissions on the order of magnitude of 1 billion t CO_2e per year that is about the emission of Germany. The loss of the trees often is a result of the "tragedy of common property" (J. Diamond: Collapse - How Societies Choose to Fail or Succeed)[17].

Appendix A contains formulas and calculations for fuel savings for the two cases:

a) Replacement of the traditional open fire (e. g. three-stone fire) by the transition to OSAT
b) Replacement of traditional charcoal cooking, also through the transition to OSAT.

The transition to OSAT means the transition to an improved stove (e. g. Ben-stove), Thermos-Technology and a powerful Solar Cooker (SK14). The remaining firewood requirement with OSAT is calculated at 400 kg/year (small sticks, annually regrown). With an annual harvest of about 10 t dry matter per hectare (higher values are possible), about 400 m^2 are to be planted for the sustainable supply of a household.

The saving of wood in case a) is more than 4 tonnes per household per year. In case b) the calculated saving of the necessary wood is about 8 tonnes per household per year. The results are shown in Table 1 in Appendix A from a spreadsheet.

[13] https://solarcooking.fandom.com/wiki/Ben_2_and_Ben_3_Firewood_Stoves; download 18.07.2022, 10:00
[14] https://cleancooking.org/ and http://aprovecho.org/publications-3/
[15] https://solarcooking.fandom.com/wiki/Heat-retention_cooking and chapter 4.1
[16] http://solarcooking.org/seifert and chapter 4.3
[17] J. Diamond: Collapse - How Societies Choose to Fail or Succeed. Publisher Viking, Penguin Group, New York (2005)

Appendix B shows the savings in CO_2 emissions through the transition to OSAT calculated according to Appendix A. For case a) the transition from traditional open fire results in an annual saving of CO_2 emissions of 6 tonnes CO_2 per household per year. For case b) is the calculated saving in CO_2 emissions more than 11 tonnes CO_2 per household per year. If multiplied by the assumed 200 million households, a CO_2 emission results in more than 1 billion tonnes of CO_2 per year, as mentioned above.

While the potential for saving emissions through cookers and thermos technology in regions of firewood crisis is high, other necessary equipment of households in developing countries, especially PV lights, save less emission. This recommends a "bundling" of household energy projects, as shown in Appendix C for a reliable supply of household energy. With a focus only on stoves, households cannot escape the poverty trap.

3.3 OSAT Household Energy Equipment

There are many successful projects to fund efficient cooking stoves for poor households in developing countries to replace traditional open fires. It should be borne in mind that this is about picking “low hanging fruits” and that great hopes can be destroyed as a result, namely opportunities to combine effective poverty reduction with climate protection.

Appendix C deals with a simplified proposal for funding to equip poor households with renewable energy technology. The aim is not only to ensure efficient stoves that make it particularly easy to save CO_2, but also, among other things, to provide a basic PV supply that only saves a little CO_2 emission, but seems necessary to overcome the poverty trap.

Credits are also important for the host countries, which, according to the Paris climate agreement, should also commit to reducing emissions and should not be deprived of the easy opportunities. A holistic design of the projects is therefore recommended in order not to destroy important opportunities for poverty reduction. The Federal Environment Agency published on November 20, 2018 that the emission of one tonne of CO_2 causes damage of 180 euros. If the household energy projects avoid around 4 tonnes of CO_2 per year over several years, the opportunity should be seized for economic reasons to pave a way out of the oppressive poverty in developing countries.

Appendix C contains a rough estimate of the cost of equipping a household with OSAT. A depreciation period of 5 years of the whole investment (300 euros) is assumed. The annual debt service is estimated at 120 euros. It is assumed that an annual saving of CO_2 of 4 tonnes per household is certified and that 30 euros per tonne of CO_2 are credited (see chapter 7). This could cover the annual expenses of 120 euros. Only a saving of 4 tonnes CO_2 per year was used to take into account that the host country also has obligations to reduce emissions in accordance with the Paris climate agreement. Therefore, a large part of the emission savings should be credited to the host country.

The Innovation Institutes should play an important role in the fair distribution of emission credits between the host countries and the funding bodies from joint projects (see subchapter 7.6).

3.4 Programs to escape from poverty trap

There are enormous opportunities from Open Source Appropriate Technology for sustainable life on our planet, for creation of perspectives, for the avoidance of damages and prevention of conflicts.

Worldwide spread of Garden Culture is fundamental, which deploys the enormous potentials of human resources, land, biodiversity, solar energy. We can build on the worldwide open-source-knowledge and preparatory work of NGOs, but a new dimension of cooperation is necessary to escape from poverty trap.

The large number of jobs to be created each year in Africa is made possible above all by the development and dissemination of Open Source Appropriate Technology (OSAT). In efforts to overcome unemployment, we should follow the recommendations of E.F. Schumacher (Small is Beautiful, chapter "Social and Economic Problems Calling for the Development of Intermediate Technology"). This advice is still barely considered, although it solves the main problem: unemployment in developing countries.

The investment cost per OSAT workplace is minimal compared to the cost of a high-tech workplace. Misleading would also be the attempt to create cheap industrial jobs in Africa. This work is very easily transferred to robots in today's industrial world (“Industry 4.0”) and would be contra productive to the goal and effort against the poverty trap.

Millions of young people in Africa could create a paradise continent if they are inspired and given effective support to learn, develop and produce together in the field of appropriate technology and horticulture instead of living without prospects. The required training places and workshops can be financed if they concentrate on appropriate technology and horticulture.

The transformation of a large part of Africa into garden land and the creation of millions of jobs could be financed through cooperation in climate protection. Gardens are certainly suitable for the sequestration of bio-carbon.

Sketch on the topic "Use of Appropriate Technology”

A scene in Zambia/Africa

Participants: a mother with two children

Son: Mom, why don't you cook us beans? They taste so good and the dry beans are cheap.

Mother: You know I have to boil the beans for 4 hours and then I have a terrible headache and the charcoal I burned costs a lot more than the beans.

Son: Yes, we learned at school that burning charcoal produces a lot of toxic carbon monoxide and that people have died from using charcoal to heat their homes.

Daughter: We learned at school that you should soak the beans in water overnight so that they soften faster when cooking. After soaking for 8 hours, they will be soaked with water and will be 2 to 3 times larger. The remaining water must be poured away and fresh water used for boiling until soft.

Mother: That's a good idea, but I think it still takes hours for the beans to cook.

Son: Yesterday our teacher showed us a basket lined with pillows and blankets. She packed a large pot with hot water in it and we measured the temperature of the water with a thermometer after 2 hours and after 4 hours. We drew a chart using these readings. The temperature in the "thermo-basket" was still higher than 80 °C after 4 hours.

Mother: It's incredible how long the water stays hot. Then all I have to do is bring the pot with the soaked beans to a boil and then pack them in this basket. After 3 or 4 hours the beans should be soft all by themselves without using any charcoal and without giving me a headache. I have a basket and I will sew the cushions today and fill them with cotton, wool or feathers.

Son: So, we're going to eat beans with the porridge tomorrow?

Mother: If I just have to boil the pot, you can have beans to eat every day. But keep in mind that we have to soak the beans overnight beforehand.

Daughter: Our teacher promised us that we will build firewood stoves in the handicrafts class that hardly need any firewood for cooking. Then you don't need to burn charcoal at all.

Mother: What competent children I have!

4. THREE EXAMPLES OF OSAT

COOKING WITH RETAINED HEAT – BEN FUELWOOD STOVE - SK SOLAR COOKER

Open Source Appropriate Technology (OSAT) means: freely accessible appropriate technology. In principle, every member of the world community can participate in the development and dissemination of this technology. The basic idea is that this enables a faster and more comprehensive solution of tasks. We would like to show examples of OSAT using a thermos technology, an efficient firewood stove and the SK solar cooker.
"What task could be greater than when all human beings work together to bridge the chasm that separates humanity and to devote all their might to a peaceful enterprise that is primarily human-centered?" [18]

4.1 OSAT-Example 1: Cooking with retained heat

If 2 billion people annually consume approx. 0.4 tonnes of firewood per person, and if cooking by retained heat saves 25% or more, then 200 million or more tonnes of firewood could be saved annually by this extremely simple thermos technology. As a result, emissions as well as health and financial burdens decrease. It is very easy to convey this helpful technique in the classroom and in the media. It is inconceivable that this opportunity is virtually untapped.
But there are encouraging news, for example a report[19] "Kenya learns to cook with solar power – even when the sun doesn't shine".

Photo 4.1: Basket with blankets and cushions

With a "hay basket" (Photo 4.1) equipped with two blankets, two cushions and a cloth to cover the sooted pot, 6 liters of water, inserted at boiling point, maintained a temperature above 80 °C for more than 4 hours. Thus, beans can be cooked during some hours in the hay basket without surveillance, fuel consumption, CO_2 emissions nor health burdens. After 15 hours from the start the temperature was still 60 °C. One can use the warm water from the basket to prepare bath water the next day without lighting a stove.

It is essential that the insulating material is well dried and that the pot contains a large content of water. Appendix D: "Notes on Fireless Cooking - Cooking with Retained Heat" gives details for the application of this underestimated technology, including safety precautions to be followed.

Sources and more information about cooking with retained heat can be found at the website of Solar Cookers International: https://solarcooking.fandom.com/wiki/Heat-retention_cooking

[18]Club of Rome: The Human Dilemma - Future and Learning. 4th ed. 1981, translated from German edition: Das menschliche Dilemma - Zukunft und lernen. 4. Aufl. 1981 (chapter V. Epilogue)
[19] http://www.reuters.com/article/us-kenya-solar-cooking-idUSKBN17C2KG

4.2 OSAT-Example 2: Ben Fuelwood Stoves

4.2.1 Components of the Ben-Stove

a) The Ben-Stove (Photos 4.2, 4.4, Drawing 4.1) has a long, pull-out ash pan with a built-in grate made of hairpin-shaped rods (Photo 4.3).

Photo 4.2: Workplace with Ben-Stove, hay basket and thermos flasks

In this way, the burning sticks are held securely, so they cannot tip over if their center of gravity shifts due to the burning.

b) The stove shell is lifted off the floor by the tripod. This ensures the supply of primary and secondary air for complete combustion. The flow resistance is not influenced by the sticks. The air supply to the fire adjusts itself.

c) The stove shell reaches temperatures slightly above 400 °C. Normal steel can be applied for the components. An optional shield around the shell protects against accidentally touching the hot shell.

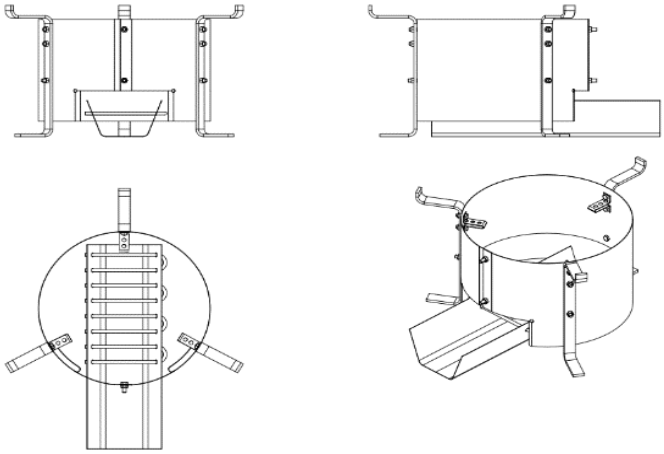
d) The simple design makes it possible to provide a special stove shell for every pot size. This enables an efficiency of approx. 40%. The Ben-P design with an oven plate or a large pan instead of a pot is also easy to implement (Drawing 4.1).
The Ben-SL takes into account a proposal from Sri Lanka with a tripod that is screwed to the inside of the stove shell. It is a good example of OSAT.

A documentation can be found at Annex H) and J) in https://solarcooking.fandom.com/wiki/Ben_2_and_Ben_3_Firewood_Stoves.

4.2.2 Specification of the Ben-Stove

Fulfillment of the OSAT criteria for the stove means above all:

a) The stove can be crafted in a simple workshop,
b) with simple materials,
c) with simple tools.
d) The stove has a long life span,
e) is adaptable to local requirements,
f) easy and safe to use,
g) suitable for all usual tasks for stoves,
h) has a high thermal efficiency (higher than 30%),
i) has an effective thermal power of about 1.5 kW.
j) A comfortable, beautiful workplace can be set up in a wind-protected place under the open sky (see photo 4.2).



Drawing 4.1: Ben-P for large pan (courtesy Quirin Möller)
The three pot supports on the inside of the stove shell made of commercially available stainless steel perforated strips also allow pots to be used.

To a): Simple workshop
A workshop possibly without machine tools, except for an electric drill, which can, however, be replaced by a manual drill or a hand punch (e.g., in the event of a power failure). Work processes are: cutting sheet metal and providing holes, bending sheet metal, cutting and bending the grate-rods.

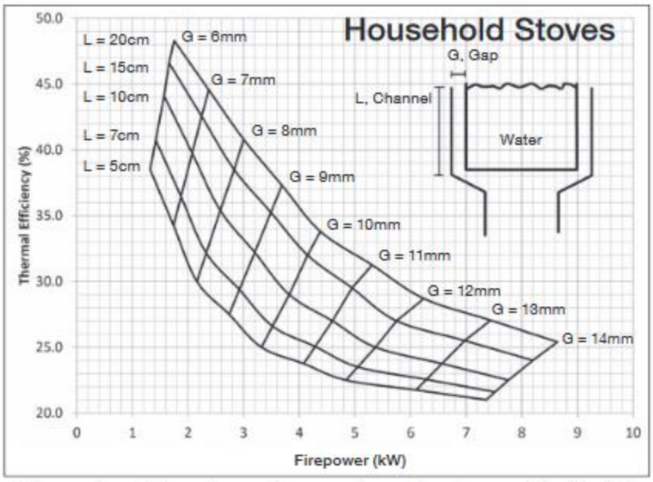
To b), c) d): Materials, tool, life span
At temperatures up to about 400 °C, normal steel is considered to be resistant. Stainless steel is not always available and more difficult to drill. During the tests, the zinc layer of the stove shell melted only slightly (melting point 419 °C). This is achieved by using primary and secondary air supplied from all sides to the burning sticks on the grate made of round steel. Thus, normal steel is suitable (except the three inner pot-supports, displayed in drawing 4.1, for which for sale punched stainless steel strip is recommended).

To e): Locally adaptable
The training time for the production of the Ben Stoves can be less than a week. During this time, the manufacture of the devices for the production in small series can also be learned. These are simple drilling and bending devices that are described on the Internet. But it is crucial that the construction is adapted to local conditions. An example of the adaptation is the Ben-SL design, the tripod of which consists of bent strip steel on the inside of the stove shell (according to a proposal from Sri Lanka).
In the Ben-P design (see drawing 4.1), the three strips of the tripod are bolted onto the outside of the shell. They can be adapted to an oven plate or large pan[20].

To f): Lighting, operation and extinguishing the fire correspond to process of simple open fireplaces. The training period for safe operation takes a few hours. The ash pan with built-in fire grate tributes significantly to save and easy operation with high efficiency. It can be pulled out of the stove to remove the ash.

To g): The shape of the support for the pot or pan can be easily adjusted.

[20] Perforated stainless steel strips are recommended for three small pot supports on the hot inside of the furnace shell. It has the necessary holes and is easy to cut and bend.



Charts for sizing channel gaps, from Dr. Samuel Baldwin's "Biomass Stoves: Engineering Design, Development, and Dissemination." (Baldwin, 1987)

To h) and i): Efficiency and thermal power:
In test operation of the Ben-stove, efficiencies in the range of 40% were achieved. This high level of efficiency requires a diameter of the furnace jacket that is adapted to the pot (gap width approx. 7 mm, see diagram from Aprovecho Handbook 2. Ed. Page 35).[21]

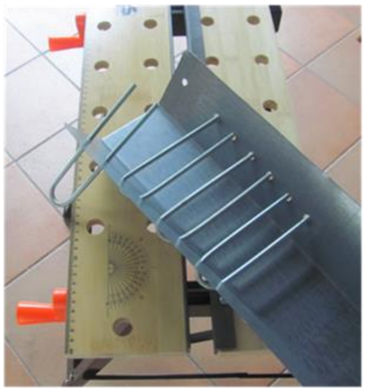


Photo 4.3: Ash pan with grate made of 4 hairpin-shaped rods

4.2.3 Fuelwood saving versus thermal efficiency

The diagram below depicts the fuelwood consumption (blue line) depending on the stove efficiency. A consumption of 10 kg is assumed for efficiency 10% (that means 1 kg for 100% efficiency). The saving (red line) is high till about an efficiency of 40%.

Photo 4.4: Ben-Stove at shelf

4.2.4 Measures to avoid exposure to smoke

- Operate the stove outdoors.
- Provide reliable air supply to the sticks on the grate for complete combustion.
- Shorten the heating time through high efficiency of the stove and use of lid on the pot.
- Easy loading with dry sticks on the grate.
- Sit sideways to operate the stove.
- Use thermos and solar technology in addition to greatly reduce active heating time.

A safety analysis (e.g., HAZOP[22]) should be performed regarding the application conditions. Safety studies should be an important task of the Innovation Institutes.

[21] Clean Burning Biomass Cookstoves, 2nd Edition, 2021. Part 1, Main content
[22] https://en.wikipedia.org/wiki/Hazard_and_operability_study

4.3 OSAT-Example 3: Solar Cooker SK12/SK14/SK1.4 and alSol1.4

4.3.1 Requirements for the solar cooker

The volume "The future of our planet"[23] contains on pages 281 and 282 a description (in German) of the possibilities of solar cooking and a photo of a SK14 solar cooker. The text contains the statement:

"Some [solar cookers] *bring water to the boil in a few minutes and reach more than 200 degrees Celsius, others work without supervision and are robust, still others only cost between five and ten marks. However, there is still no model available that combines all of these properties."*

Photo 4.5: Encuentro Solar at Parque de las Ciencias, Granada/Spain

The demand for high output and high temperature is met by the SK-type solar cooker. But the other requirements can also be achieved with this cooker, even if it doesn't look like it at first glance:

a) It works without supervision - or it needs no more supervision than an electric or gas stove. It turns itself off more and more after half an hour, so that the risk of unattended cooking is lower than with an electric or gas stove. It should be noted that many dishes only have to be boiled briefly and are then cooked in the thermos-basket and are ready at the right time.

b) The SK-coolers are robust and are designed for a long service life. Maintenance and repair can be done with simple workshops.

c) The price can be reduced to less than some euros (protection fee) through greenhouse gas compensation, since between one and ten tonnes of CO_2 can be saved per SK-cooker per year. This enables financing of solar cookers in the framework of cooperation for saving CO_2-emissions. In this way, the solar cookers can be made accessible even to the poorest (see chapter 7).

The catalog of requirements did not call for a built-in heat storage that would make it possible to cook in the solar cooker at night. In the past, this demand has led to expensive solar cookers, but instead of this, the cooking time and the mealtime are reliably decoupled by simple thermos containers for cooking with retained heat. This achieves additional advantages, as mentioned above.

4.3.2 Spread of the parabolic solar cooker

The in the past often expressed opinion, that solar cookers would not be accepted was also not repeated. For a long time, the blame for the low spread of solar cookers was shifted to those affected by the firewood crisis and it was not noticed that large deficits in the cookers were the reason for the rejection. The acceptance of suitable solar cookers was demonstrated in the GTZ solar cooker field test in South Africa (see 4.3.3 Test results).

It should be noted that the SK cooker has additional uses, including for generating income (see photo 4.6). A big advantage is the large amount of water that can be boiled/sterilized with the SK cooker.

[23] Brockhaus Reihe "Mensch - Natur - Technik", vol. Die Zukunft unseres Planeten. F.A. Brockhaus, Leipzig, Mannheim (2000), ISBN 3-7653-7946-8

Photo 4.6: Products for generation of income with the SK parabolic solar cooker; a wide range of possibilities arise from baking and preserving food in the high-performance solar cooker

The high performance of the SK12/SK14 with a diameter of 1.4 m suggests using also SK-type cookers with a diameter of 0.8 m or 1 m. If the pot is appropriately sized, the output is roughly proportional to the square of the reflector diameter (proportional to the reception area). The cooker with a diameter of 1 m has half the performance of the cooker with 1.4 m diameter. The smaller cookers are particularly beneficial in school programs (see chapter 8.)

Significant progress in reflector cookers has been achieved in recent years with the development of highly efficient and durable high-gloss aluminum sheets[24].

The development aid group EG-Solar e.V.[25] of the state vocational school in Altötting/Germany has been committed to the solar cooker program since 1989 and has established and supported workshops worldwide. More than 40,000 parabolic solar cookers of SK-type have been supported.

Photo 4.7: Second International Solar Cooker Test, Plataforma Solar Almería, (1994). Courtesy European Committee for Solar Cooking Research (ECSCR).

[24] https://alanod.com/en/industries/solar/reflective-surfaces
[25] http://www.eg-solar.de

4.3.3 Test results

Selected Results of the 1994 ECSCR Comparative Solar Cooker Test and 1998/99 Tests in South Africa

Dimensions (cooking pos.):	143 x 163 x 125 [cm]
Number of pots and nom. volume:	1 removable pot (12 l)
Test pot content:	6 l
Aperture surface:	1.54 m^2 (reflector)
Heating time (water):	
- cold start (40 - 80°C)	*27 minutes/**27 minutes/***30 minutes
- cold start (40 - 96°C)	*44 minutes/**38 minutes/***39 minutes
- hot start (40 – 80°C)	-
- hot start (40 – 96°C)	-
Max. temperature (oil):	*198°C after 130 minutes
Continuous cooking:	*boils 48 l of water in a day
Heat loss with lid open:	*cools from boiling temperature to 83°C in 15 min
Comments:	excellent thermal performance for a concentrator-type cooker; small nominal pot content for this size of aperture; requires regular tracking
Handling:	easy, one-step access to pot; easy tracking, but level ground required; acceptable operation, but difficult to relocate
Application:	cooker for large families and, in modular application, for small institutions; suitable for cooking and roasting
Evaluation for technology transfer/local production:	easily reproducible; reflector material must be protected against corrosion; a folding type of steady stand is under development; transport and assembly require optimization
Contact address:	Dr. D. Seifert, Siedlungsstrasse 12, D-Neuötting, Germany Tel./Fax: +(49)867170413, Email: bdiv.seifert@t-online.de
Legend:	*ECSCR; tested in SA; **European model, *** prototype built in SA

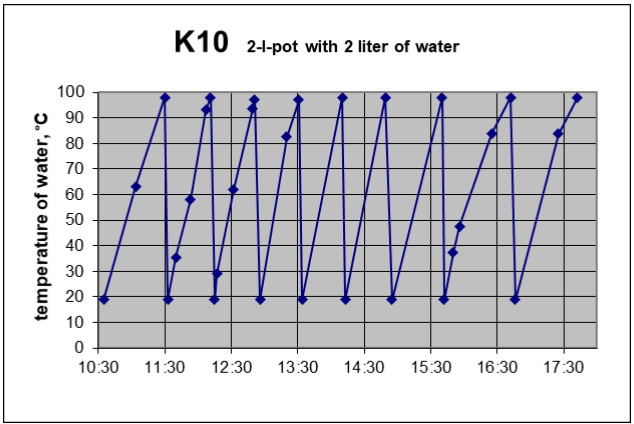
Table 4.1: Test results of SK12/SK14 from the GTZ brochure "Solar cookers in developing countries", Eschborn
http://www.gtz.de/de/dokumente/de-solarkocher-1999.pdf

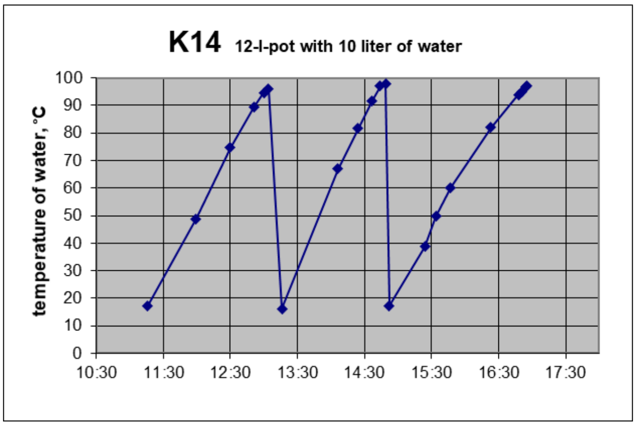
The tables below show test results with kit cookers from the manufacturer Koch Anhängerwerke, Winsen/Germany, K5 to K14. The numbers indicate the reflector diameter in decimeter.

SK Solar Cooker Test	place of test **D-84524 Neuötting**	latit. 48,2° n., long. 12,7° e.
on 1st Oct. 2002	test performed by **Dr.-Ing. Dieter Seifert**	
start: 10:30	ambient temp.: 11 °C (9:30), 18 °C (12:30), 20 °C (15:00)	
time: MESZ	measurement water temp.: Digital Thermometer -40°C..120°C	
from about 10 o'clock clear sky, no wind	start of boiling at about 95 °C	

Cooker	Pot	Surface	Lid	Water load
K5	0,75-liter-pot, 12cm, stainless steel	black colour	glass	0,5 liter
K6	1-liter-pot, 15cm, steel	black, ename	glass	1 liter
K8	1-liter-pot, 15cm, steel	black, ename	glass	1 liter
K10	2-liter-pot, 20cm, steel	blue, enamel	glass	2 liter
K14	12-liter-pot, 28cm, steel	black, ename	1st run:black enamel/2.,3. ru	10 liter

Summary	**K5**	**K6**	**K8**	**K10**	**K14**
cooked quantity of water	3 liter	7 liter	10 liter (s.a.)	18 liter	30 liter
power (medium)	60 Watt	117 Watt	188 Watt	315 Watt	614 Watt
*) medium value taken from run with shortest cooking time					





Comment on the test results:

In the ECSCR comparison test, the parabolic cooker SK12 (1.4 m reflector diameter) achieved the highest temperature (198 °C) of the 25 solar cookers compared. This allows it to be used for all tasks, including roasting, deep-frying and baking.

The SK12 boiled 48 liters of water per day; only a very large "flat-plate" cooker (collector cooker) reached a larger volume (65 liters/day).

The water boiling test with the parabolic cookers (K5, K6, K8, K10, K14) was carried out 10 degrees further north on October 1st, i.e. not in midsummer, in the period from 11:16 a.m. to 4:55 p.m. Therefore, the amount of water boiled in one day was less than what was measured on the solar platform in Almería.

In the GTZ acceptance test in South Africa, the SK12/SK14 was certified with the highest level of acceptance.

4.3.4 Call for solar cooking

From the article[26] of Dr. Sena Gabianu (Program Officer of the World Bank): "AFRICA'S GROWING AWARENESS OF PROBLEMS OF ECOLOGY AND ITS LINKS TO SOCIAL AND ECONOMIC DEVELOPMENT" at a seminar held at Neuendettelsau (Germany) in May 1996, which is still of actuality:

> *"There is a project running in Ethiopia right now being extended by ILO to help the Women Fuel Wood Carriers. This is a very special group of women, very poor, who can be seen carrying loads of wood on their backs from far off forests to sell in the cities. … They are really the poorest of the poor. But as they told us, they do not need to beg on the streets. The project is helping them to get a sense of self adequacy and dignity. They are to be helped with a micro-credit scheme to get other skills. They know they are being blamed for unauthorized cutting down the forest, destruction the young trees and even the collection of leaves which in the past fell by themselves and regenerate the land, but they don't know else to live. … There is promise in Solar Energy but as one lady told us at a seminar, she has heard so much about solar energy and how abundant the sun is, yet she has to look up to the skies every day, watch the sun go from east to west, shedding a lot of its energy and there is no way she can bring it down to do her cooking with. May be, she added, those of you who have education can help us."*

Photo 4.8: Woman in Zanzibar carrying firewood
Photo courtesy Fundación Terra, Barcelona,
https://www.terra.org/categorias/articulos/lamentaciones-de-un-anciano

[26] Source: O. Ischebeck (ed.): FROM FOSSIL FIRE TO THE SUN – Renewable Energies for Sustainable Development and Employment in Africa, Akademischer Verlag Munich, 1997, pp. 18-19.

5. OVERCOMING FIREWOOD CRISIS

5.1 No Choice?

In a broadcast[27] on August 3rd, 2015 entitled “Zambia: Forests to charcoal” two villagers are shown in Zambia cutting down one of their last large trees (see photo 5.1). It was reported upon "poverty as a climate killer". The people of these poor villages feel they have no choice but to starve or sacrifice their trees to make charcoal for the townspeople's kitchens. This terrible struggle for survival causes more than six tonnes of CO_2 emissions per household per year, see Annex B).
This corresponds to the emission of a car trip approximately the length of the equator. (0.14 kg CO_2/km * 40000 km = 5600 kg CO_2)

Photo 5.1: Source of photo see footnote

5.2 About costs due to failure to protect the environment

A press release[28] issued by the Federal Environment Agency of Germany on November 20, 2018, states: *"High costs when environmental protection is neglected - One tonne of CO_2 emissions causes damage worth 180 euros – German Environment Agency publishes updated cost rates"*.

According to that, the annual emission of CO_2 of 6 tonnes from the household cause 1000 euros of damage *per year*. This is a multiple of the costs required per household to overcome the firewood crisis. And that doesn't capture the full damage of this tree destruction. We all know since school days the diverse value of trees. A look at Haiti's barren landscape with eroded soil shows the impact

[27] http://www.daserste.de/information/politik-weltgeschehen/weltspiegel/sendung/sambia-holzkohle-100.html
[28] https://www.umweltbundesamt.de/en/press/pressinformation/high-costs-when-environmental-protection-is

of deforestation of charcoal. African countries such as Zambia, Madagascar and Ethiopia are suffering the same fate as Haiti. The threat of this poverty trap has been known for decades.

Prof. E.N. Chidumayo et al. write about the "Dry Forests and Woodlands of Africa" in their book: [29]
*"The dry forests and woodlands of sub-Saharan Africa are major ecosystems, with a broad range of strong economic and cultural incentives for keeping them intact. However***,** *unlike tropical rainforests, few people are aware of their importance, despite of their status as homes to more than half of the continent's population."*

5.3 Proposals for overcoming the firewood crisis by Open Source Appropriate Technology

The photo 5.2 and the table from Annex A) illustrate the reduction of fuelwood demand of a traditional household using open fireplaces ("three-stone fire") to less than 10% by transition of households to OSAT (efficient fuelwood stove, thermos technique, efficient solar cooker). The left arrow in the table below indicates the reduction from 4680 kg wood to 414 kg wood per household per year.

A reduction to less than 5% (saving more than 95%; right arrow in the table) applies to the transition from charcoal to OSAT. Trunks and thick branches are used to produce traditional charcoal.

Photo 5.2: Comparison fuelwood consumption of three-stone-fire with OSAT

Table 1: Calculation of Reduction of Wood Consumption through Transition to OSAT with improved Stove, Thermos-Technology and Solar Cooker SK14

Consumption of Wood per Household per Year	Unit	Fuelwood traditional	OSAT	Charcoal traditional
Net Calorific Value NCV_Wood (15% Humidity)	MJ/kg	15,6	15,6	
Net Calorific Value NCV_Charcoal	MJ/kg			29,5
Thermal Efficiency η of Stove		**12%**	41%	**20%**
Fuel Consumption per Household per Year (Senegal-Doc.)	kg fuel/year	**4680**	1370	1485
Effective Energy Demand E_eff per Household per Year	MJ/year	8761	8761	8761
Mass Ratio Wood/Charcoal (default value IPCC)	kg/kg			6,00
Percentage of Saving f_thermo via Thermos Technique		45%	45%	45%
Percentage of Saving f_solar via Solar Technique (SK14)		45%	45%	45%
Consumption of Wood per Household per Year			*small sticks*	*branches and stems*
Without Thermos- and Solar Technique	kg wood/year	**4680**	1370	8909
Including Thermos- and Solar Technique	kg wood/year		**414**	

Result: Through transition from traditional cooking to OSAT - Open Source Appropriate Technology (here: Ben-Stove, hay basket, Solar Cooker SK14) annual wood consumption of the household can be reduced from 4680 kg/year to 414 kg/year. Transition from traditional charcoal stove to OSAT enables a reduction of wood consumption (for charcoal production) of 8909 kg/year to 414 kg/year per household.

In contrast, thin sticks of short rotation plantations and annual harvesting are suitable for the use of efficient OSAT firewood stoves.

Result: With OSAT, there is no longer a need to cut down trees for firewood or charcoal.

[29] E.N. Chidumayo et al.: The Dry Forests and Woodlands in Africa.
Earthscan - Publishing for a sustainable future. London, Washington D.C. (2010) ISBN 978-1-84971-131-0

5.4 Quotation about a project in Indian households from a thesis about "Cooking for the future"[30]

"In the morning, Lata heats 6 liters of water for the family to wash. Between 10 a.m. and 11 a.m. she starts cooking. For this she needs about 5 liters of water. At 6 p.m. she cooks dinner. In total, the family consumes around 10 kg of wood per day. To do this, Lata, her sister and sometimes her husband collect wood for go at least two hours a day. Lata reports of arguments that often arise among neighbors and of discussions about the dangers that lurk. When the women are traveling alone, they try not to collect too far away from their homes in the settlement. There have already been violent attacks by strange men who ambush women outside of the settlements. Wood collectors are further endangered by wild animals. Because of the heavy rain of the monsoon season this family cannot do without cooking with wood. The 10 liters of petroleum provided by the government per household and month are not enough for the family of six. So, they must collect and store wood in the dry season for the rainy season."

Photo 5.3: Solar Cooker Course at Muni Seva Ashram (Source: Courtesy V.F. Seifert)

[30] Quotation from: Veronika F. Seifert: Kochen für die Zukunft – Ein Projekt zur „nachhaltigen Bildung“. Magisterarbeit Philosophische Fakultät Universität Passau (Cooking for the future - A project for "sustainable education"). Translated excerpt from subchapter 3.3.1 Long-term project in Indian households

5.5 Lamentation of a Village Elder[31]

Photo 5.4: Courtesy of Michael Hoenes, Lesotho

Today we logged our last tree.
We will make charcoal from it.
Just like before, from all the other trees of our village.
We need the income.
But now we have no more trees.
We had no choice.

We will live for some weeks from our last tree.
It's hard work to fill the kiln.
The smoke burns our lungs.
The wood should be dried before we stack it in the pile.
But we cannot wait.
We have no choice.

We were told that we can cut down our trees
If we plant small saplings.
But the goats have eaten the plantlets.
It takes decades until a seeding becomes a tree.
Now the chain is broken.
We believed we had no choice.

Our neighbors did the same.
They have only a few trees left.
They cannot share them with us.
They too had planted small trees.
But the plantlets dried up,
Because they were not cared for.

Previously, there were many trees in our villages.
We have taken dry branches from them to cook.
Then we began to cut the trees,
For charcoal, for income, for our children.
But we did not see that we sacrificed their trees.
We trusted we would always have trees.

There were people who warned us against the use of charcoal.
We laughed:
There are so many trees in our village,
They will grow again.
The charcoal gives us income.
We need it for our children.

[31] Article prepared by Dieter Seifert, who attempts to express his desperation to see how the African continent does not support appropriate technology to fight against the firewood crisis as expressed in his article "Traditional charcoal in Africa – a continent in danger". The article was translated into poetic Spanish by Jordi Miralles and provided with other pictures: http://www.terra.org/categorias/articulos/lamentaciones-de-un-anciano

At first there we saw almost no change.
Then more and more trees were missing.
Now I can hardly see a tree at the horizon.
Our ancestors gave us a land with many trees.
We have lost the heritage.
Our children accuse us.

It is terrible now to see our village without trees.
The shadow of the trees that cools the ground is missing.
No leaves are catching the rain drops.
There are no trees to hold the soil against the wind.
The rain no longer penetrates the ground,
Runnels run across the ground and sweep away the earth.

There were people who urged us to use solar cookers.
To cook, to fry, to bake, to conserve.
We only had questions:
What to do when sun is not shining?
Shall we not eat more after sunset?
Is it really possible to keep food warm in a basket for
hours
And to boil beans, almost without fuel?

We were told that good stoves consume almost no wood,
That dry wood doesn`t damage the lungs.
We were told about small biogas-plants.
But we thought that we cannot realize these things.
We were thrilled by the charcoal.
And now we have no trees anymore.

Oh, why did we let pass so much time?
Maybe it is not too late for change.
We want to turn our village into a wonderful garden.
We want to learn how to build solar devices.
We want to plant trees and make sure
That our grandchildren will inherit trees again

And esteem them as a present from heaven.

Photo 5.5: Solar cooking in Mali. Source: Süddeutsche Zeitung LKR, May 30, 1994,
Article: "Wunder dauern etwas länger“ (Miracles take a little longer)

6. GARDEN CULTURE – A BREAK THROUGH INNOVATION

6.1 Gardens with a great history and great current importance

Garden culture has a millennia-old history. Drawing on this wealth of experience and transforming Africa into a "garden continent" is certainly one of the most inspiring tasks of the century which could create millions of jobs annually.

The global importance of gardens and appropriate water technologies as breakthrough for innovations is barely recognized. There is an incredible abundance of opportunities to overcome poverty and the lack of prospects in Africa and to surpass the UN goals for sustainable development.

Monastery gardens, kitchen gardens and famous urban gardens are also models of self-supply. "*The city maps of Augsburg from the Middle Ages to modern times show extensive garden plots following the city wall outside the fortifications and surprise with large gardens, in some parts also within the walls*." (R. Pfaud)[32] . The map of Wolfgang Kilian from Year 1626 shows that the garden areas outside the city wall are as large as the city area within the wall. Founded 500 years ago, the "Fuggerei" in Augsburg is the oldest social settlement in the world. It is endowed with exemplary gardens.

Every household should have access to a family garden and the younger generation should have the opportunity to become a gardener.

6.2 Garden culture (Horticulture) – a way out of misery

When referring to garden culture should be considered teaching of gardens, botanical gardens with cultivation of adapted plants, gardens in arid areas, carbon-storage in soil and soil improvement through bio-carbon, water storage, village development and avoidance of rural exodus.

A new gardening culture could be the breakthrough innovation which shows a solution for great challenges of our time. It can offer the humane solution to social issues needed in Africa.

Dissemination of garden culture should be one of the most important tasks of the Innovation Institutes (Chapter 2).

The Barli-Institute for rural women[33], founded by Dr Janak McGilligan in Indore is exemplary also for garden culture for a pleasant living in the countryside.

Photo 6.1: Children in Lusaka. They need gardens.

[32] R. Pfaud: Das Bürgerhaus in Augsburg. (The citizen house in Augsburg) Ernst Wasmuth Tübingen, p. 107

[33] https://www.barli.org/

6.3 Inspiring prospects due to garden culture

Garden culture can prevent the growth of slums. Instead of refugee camps and "reception centers", exemplary sites are needed to provide people better prospects, when forced to leave their homes. Inspiring prospects for millions of young people are urgently needed, rather than just providing them basic livelihoods. A comprehensive concept for "garden communities" would also improve acceptance in the reception area. These garden communities would create valuable solutions that are exemplary for host countries and offer highly respected opportunities through appropriate technology and diverse garden culture.

6.4 About private gardening[34]

a) Households in developing countries often have small gardens to grow their own vegetables and fruits. But this chance in the fight against hunger is not consequently in use.

b) Private gardening should be enabled and encouraged for all interested households.

c) Children should learn at school how to cultivate vegetables and fruits in small containers.

d) Public botanical gardens should demonstrate the possibilities and necessities.

e) The access to seeds and seedlings has to be organized with support of the public authorities, possibly in combination with botanic gardens.

f) Availability of containers play an important role for the acceptance of intensive gardening.

g) The use of appropriate containers and foils for gardening and the prevention of soil salinization should be pursued. Production of containers in large quantity is easily possible by use of plastic waste and recycling (an environmental contamination in many regions and the sea).

h) Of course, flowers should also be grown in the micro habitat as it has long tradition in kitchen gardens worldwide.

i) We cannot overestimate the opportunities and advantages of gardening. Sustainable civilization requires we all become gardeners, at minimum micro-gardeners.

6.5 Garden communities – a break through innovation

The spreading and use of the garden culture in Africa using local and available means is an immense task and should also include adapted intensive agriculture. Unfortunately, the poorest in society are often the least informed about available gardening opportunities. A comprehensive concept for "garden communities" would also improve acceptance in host countries. These communities would create valuable solutions and offer highly respected opportunities through appropriate technology and a variety of garden culture.

Worthy settlements for refugees should replace dismal refugee camps and desolate "reception centers" and are financially feasible; see also Chapter "Refugees" in the manual "WORLDCHANGING".[35]

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[34] Literature e.g.: John Seymour: The new complete book of self-sufficiency. Dorling Kindersley Ltd.

[35] A. Steffen (ed.): WORLDCHANCING – A User's Guide for the 21st Century. Abrams, N.Y., p. 203 ff

A new gardening culture could be the much-needed breakthrough innovation: The spread of garden settlements instead of rural exodus to the slums of cities. If 2000 family gardens with 500 square meters each are forming a garden city with community facilities, then such a garden community has an area requirement of approximately one square kilometer and accommodates approx. 18,000 inhabitants. If we assume that also a 35 times as large economic area (for small and medium businesses, farming, forest and short rotation plantations, pastures, commons, etc.) belongs to the garden community, then 36 square km for 18,000 people are needed (500 inhabitants per square km). In an area of the size of Zambia (about 750,000 square km), about 1/3 billion people could lead a sustainable life in a pleasant environment.

6.6 Bio-carbon storage in the soil for soil improvement and as a carbon sink

Backyard Gardening can play an important role in overcoming poverty. There are encouraging successes in increasing yields with bio-carbon.

Gardens are suitable for the sequestration of bio-carbon. The transformation of a large part of Africa into garden land and the creation of millions of jobs could be financed through cooperation in climate protection. The "carbonization" of the soil through the permanent incorporation of bio-carbon (biochar) can help to decarbonize the atmosphere. Garden settlements can thus be used as carbon sinks, with the bio-carbon being used to improve soil fertility.[36]

"I fully agree with your conclusion in the essay in the direction of "garden culture" based on my Africa experience. From 2009 to 2016 we only served farmers in Ghana with biochar (they only paid around 10-15% of the costs we incurred). It wasn't until 2016 that we really realized that we could use "garden culture", i.e. backyard gardening, to get a multiple of the local added value out of the franc we invested in terms of food production. Why? Because the farmers can only cultivate and harvest basic products (maize, sorghum) that produce little yield on the soil that has been improved with biochar, whereas the gardeners can grow and harvest 3 times a year. Because in every village there is a minimum of water, so that the plants in the backyards can be supplied with sufficient water even in the dry season. In addition, there are many more varieties of useful plants in backyard gardening that the Gardener can select and cultivate in order to get the maximum yield from the emerging market situation."[37]

[36] U. Scheub, S. Schwarzer: The Humus Revolution "How we heal the soil, save the climate and create the nutritional turnaround". oekom-Verlag München, 2nd edition 2017 (in German)
[37] Personal communication (translated e-mail 16.10.2020) by F. Jenny, Agric Society Switzerland Ghana - ASSG https://assg.info/125/projekte/ertragssteigerung-backyard-gardening

6.7 Recommendations of Günther Kunkel for gardening in arid zones[38]

Photo 6.2: G. Kunkel in his garden in an arid area of Almería / Spain

Günther Kunkel, biologist and author, lived many decades in arid regions of the earth and has published scientific books and articles. He started and realized projects to cultivate arid areas, together with his wife, Mary-Anne Kunkel, an artist, who illustrated his books. The following points are taken from an interview he gave in his garden in an arid zone in Almería:

1) Situate water containers above the area to be cultivated to enable irrigation without pumps.
2) Terracing of the area is recommendable when possible and when it avoids environmental damages.
3) A cover of stones or grit can reduce losses of water.
4) Another possibility to avoid water losses is the use of plastic foils.
5) Use of indigenous plants are preferred due to their ability to withstand draughts.
6) Resistant accompaniment plants should also be planted adjacent to the indigenous plant to ensure a durable plant cover.
7) The experiments should begin with a multitude of small sectors to gain experience.
8) Fencing is recommendable to protect the vegetation against grazing animals.
9) Dry walls serve as protection against erosion; but care has to be taken for percolation and for overtopping.
10) Walls also protect against drying by the wind.
11) Do your work with caution, avoid levelling and avoid large monoculture.
12) Irrigate at the right time; newer at sunshine.
13) Irrigation is necessary mainly in the initial phase; drip irrigation has the disadvantage that the formation of roots is weak, so that the transition to the phase without irrigation is delayed.
14) Cultivation has to take in mind the seasonal conditions of the region, e.g., the planting time has to be coordinated with rain season.
15) Specification of water needed cannot be done exactly. There are many factors influencing the necessary amount of water.
16) G. Kunkel recommends contacting experts, e.g. Prof. Dr. H.N. Le Houérou, France, and literature cited in the his book with illustrations of Mary Anne Kunkel.[39]

[38] Interview given to Imma and Dieter Seifert in July 2004 in Vélez Rubio / Almería
[39] https://www.lafertilidaddelatierra.com/product_author/gunther-kunkel-y-mary-anne-kunkel/

6.8 Hope through the Great Green Wall[40]

The proposals can be linked to the Great Green Wall program which raises great hopes:

"The Great Green Wall is taking root in Africa's Sahel region, at the southern edge of the Sahara desert - one of the poorest places on the planet. More than anywhere else on Earth, the Sahel is on the frontline of climate change and millions of locals are already facing its devastating impact. Persistent droughts, lack of food, conflicts over dwindling natural resources, and mass migration to Europe are just some of the many consequences. Yet, communities from Senegal in the West to Djibouti in the East are fighting back. Since the birth of the initiative in 2007, life has started coming back to the land, bringing improved food security, jobs and stability to people's lives."

7. COOPERATION ON CLIMATE PROTECTION – COMPENSATION OF CO_2 EMISSIONS AS A GLOBAL OPPORTUNITY

7.1 Generation of Carbon Credits

A global cooperation on climate protection was defined as the Clean Development Mechanism (CDM)[41] in Article 12 of the Kyoto Protocol. It enabled the financing of climate protection projects in developing countries by companies of industrialized countries, whereby the emission savings through CDM projects were credited to the project partners in industrialized countries as tradable emission credits (carbon offsetting). It was the aim of this "flexible mechanism" of the Kyoto Protocol to minimize the costs of CO_2 savings and to promote sustainable development in developing and emerging countries through transfer of appropriate technology. The original CDM is no longer suitable because reduction commitments required by the Paris Climate Agreement also includes participation of developing and emerging countries. A replacement of the CDM, taking into account the Paris Climate Agreement, is in preparation. In the field of voluntary compensation (for example in air traffic) Voluntary Emission Reductions (VERs) continue to be valuable, especially those verified by the "Gold Standard."[42]

7.2 Misunderstandings about offsetting emissions

The vast opportunity by the combination of climate protection and poverty reduction through global cooperation is still far too little recognized. There was and there is resistance and misunderstanding about offsetting emissions. It was said that Clean Development Mechanism (CDM) was a trade in indulgences, one could simply buy off one's climate guilt with it.
In our lectures on CDM and poverty reduction, we advised the critics to compare the two scenarios, a) "business-as-usual" in which the firewood crisis progresses and trees as firewood or charcoal go up in flames. Or b) equipping poor households with sustainable technology to overcome the firewood crisis, combined with other benefits.

These traditional households cause annual emissions per household comparable to a car trip around the globe. Poor households emit hardly any CO_2 if sustainable technology is made accessible to them

[40] https://www.greatgreenwall.org/about-great-green-wall
[41] https://cdm.unfccc.int/
[42] https://www.goldstandard.org/

as well as many other benefits for their households. Thus, each household can save several tonnes of CO_2 emissions per year. This sums up to a total of approx. 800 million tonnes annually; that is in the order of magnitude of Germany's annual emissions.

We should note that the German Federal Environment Agency has determined that every tonne of CO_2 emission causes damage worth 180 euros (see 5.2). We have to pull out all the stops, because since the German Physical Society first warned of the climate catastrophe in 1986, emissions have not been reduced by 2% per year, as the warning demanded - on the contrary.

7.3 About problems of market mechanisms for emission reduction and solutions

The generation of a large number of very cheap emission credits (Certified Emission Reductions, CERs) has contributed significantly to the collapse of the CER market in recent years. From 2011 onwards, the CER price dropped over the years to less than 0.5 euros.

Generation of carbon credits of high quality is tied to a complex and lengthy process and to competent actors. For the implementation of extensive compensation programs, new ways must be taken to generate the required large number of valuable credits.

Instead of striving for the cheapest compensation, more than the calculated emissions should be compensated. A large part of the emission savings should be credited to the host countries because they also have emission-saving obligations under the Paris Agreement (in contrast to the superseded Kyoto Protocol).

The aim of CDM was to use market mechanisms to achieve the required reduction of emissions at the lowest possible-cost and by the involvement of the developing countries. The free tradability of the Certified Emission Reductions (CERs) is to be viewed critically, if cheap CERs flood the market by use of free trade. The target of cooperation should be to clearly be committed to and focused on emission reductions.

Striving for the cheapest reductions is contra productive and risky. An almost unlimited volume of trade could arise “when not doing harm” is rewarded and replaces strict environmental legislation. At least, these emission reductions should only be awarded for the CO_2 balance of one's own country and not for trading.

The decisive factor is not that certificates are traded, but rather sustainable activities are implemented that effectively lead to a reduction of greenhouse gas emissions and the greenhouse gas inventory of the atmosphere. A contribution to limiting the greenhouse gas concentration in the atmosphere can only be made if the certificates are retired, but not used in full to offset emissions. Compensation costs are relatively low and easy to finance. Innovation institutes can make a significant contribution to the elaboration of the demanding documentation and monitoring for cooperation projects.

The financing of such activities should be greater than only to compensate emission obligations. Additional voluntary compensation incentives to limit the greenhouse gas concentration should be considered.

7.4 Voluntary Emission Reduction (VER)

In the case of voluntary offsetting, abuse can be avoided if the emission credits (Voluntary Emission Reductions, VERs) are not traded but issued in the buyer's name. Such projects for voluntary compensation are already being developed and published by aid organizations and their partners in developing countries. A detailed description of voluntary compensation is contained in the book[43] by Prof. F.J. Radermacher: "The Billion Joker - How Germany and Europe can revolutionize global climate protection" (published in German). The integration of emission compensation into a comprehensive, common good-oriented transformation towards sustainability is necessary.

The book of F.J. Radermacher describes opportunities for compensation of large amounts of greenhouse gas emissions through global cooperation. In his book, Radermacher shows ways in which the main emitters can and should offset their emissions account by voluntarily offsetting climate gas emissions. Compensation is provided by emission reduction measures (technology transfer, efficiency increase) and permanent carbon storage (especially in the form of bio-coal for soil improvement in degraded soils). It is stressed by Radermacher that the immense opportunity of emission compensation must not be destroyed by misinformation.

Radermacher's book emphasizes also the importance of carbon storage in the soil. Gardens are certainly suitable for the sequestration of bio-carbon. The transformation of a large part of Africa into garden land and the creation of millions of jobs may be financed through cooperation in climate protection.

The transformation by cooperation in the compensation of CO_2 emissions can open up many opportunities, not only for climate protection. High-quality emission compensation results in a variety of co-benefits in the host countries.

7.5 Replacing of the Clean Development Mechanism (CDM)

When replacing the CDM under the Paris Agreement, the benefits should be continued but known and harming disadvantages eliminated. Through global cooperation on climate protection, a concept can be implemented that comprehensively and permanently overcomes the misery in developing countries. The hitherto customary restriction to projects that focus on specific singular topics and on cheap emission reductions should be overcome. The fundamental improvement of living conditions in Africa through a major transformation requires the creation of African sustainable development institutes. For this century task, a corresponding "infrastructure" with the necessary competence is needed in Africa, i. e. institutions for the sustainable development of the continent.

Otherwise, destabilizing side effects can be expected, as compensation projects can lead to more emissions through the rebound effect or to emissions elsewhere (leakage issue), or the savings may have completely different effects than improving local living conditions.

7.6 Innovation Institutes as carriers of climate protection projects

The following flow chart contains a proposal for adapting the CDM to the requirements of the Paris Climate Agreement. The flow chart shows a central role of the proposed African Innovation Institutes. They should be responsible for the project planning process and in charge of project implementation. The financial means are given by the donors in Europe to a Climate Fund, which

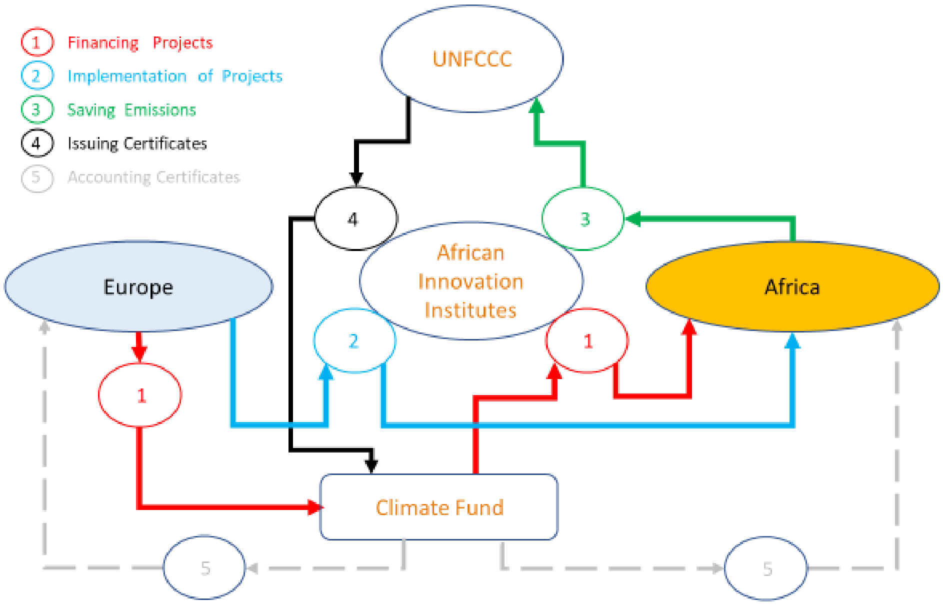
[43] Prof. Dr. Dr. F.J. Radermacher: Der Milliarden-Joker – Wie Deutschland und Europa den globalen Klimaschutz revolutionieren können. Murmann Verlag (2018)

takes over the financing of the projects and receives the Certificates approved by UNFCCC for the emission savings achieved.

The agreed share of the Certificates will be allocated to the funding bodies (official or private) in Europe, who will retire them (close them down) to meet part of their commitments.

The other part of the certificates is used by the host country to comply with their Nationally Determined Contributions (NDCs). This part is also not traded, but retired. Otherwise, the allocation of the emission savings would be problematic.

FLOW CHART OF THE PROPOSED PROCESSES FOR FINANCING OSAT PROJECTS



The "Allianz für Entwicklung und Klima" (Alliance for Development and Climate)[44], which was launched by the German Federal Ministry for Economic Cooperation and Development, is a foundation that promotes non-governmental engagement while promoting sustainable development and climate protection.

With regard to the topics addressed in this chapter, especially with regard to global cooperation, reference is made to studies by the Wuppertal Institute. “*The Wuppertal Institute sees itself as a leading international think tank for sustainability research focused on impacts and practical application. The organisation's activities are centred on developing transformation processes aimed at shaping a climate-friendly and resource-efficient world.”*[45]

[44] https://allianz-entwicklung-klima.de/en/
[45] https://wupperinst.org/en/the-institute

8. PROPOSALS FOR A GLOBAL SCHOOL SOLAR COOKER PROGRAM

8.1 A wealth of opportunities - why parabolic solar cookers are much more than devices for cooking

Imagine you are a teacher and you have decided to explain to your students how a solar cooker works. Then it would be helpful if you could present such a device, you could show the path of the sun's rays to the cooking pot by means of light and shadow, talk about the conversion of a large part of the radiation into heat, which heats the pot and boils the water in it. You could explain the physical processes and deal with these processes in detail, and make calculations, for example on performance and efficiency, optics and heat transfer.

Photo 8.1: Solar project week at Antoniushaus School Marktl/Bavaria

However, with these demonstrations and explanations alone many essentials of the possible opportunities would be lost. Solar cookers offer such a wider wealth of opportunities that go far beyond the explanation of just the physical processes. These topics could easily be taught in all school subjects for better knowledge and awareness. The solar cooker also offers the opportunity as an instrument of experiential teaching.

Our goal should be aimed to have children around the world to build solar cookers from kits, learn about the invaluable variety of uses, and participate creatively in designing instruments and discovering additional uses. If global collaboration then unfolds - the impact of this global solar cooker program can be immeasurable. An example and description of the chances by use of the parabolic solar cookers as an instrument for environmental education is documented in the diploma thesis[46] of Birgit Seifert. The program can support the urgently needed changes to save our earth’s resources and for worldwide solidarity in coping with global threats and crises. The solar cooker program can help transition from increasing awareness of global tasks to joint concrete action and is as an encouraging example of the concrete possibilities for shaping a decent future on our planet.

In the solar cooker program, the young people can practice how to produce components from simple semi-finished products (see photo 8.1). Simple devices and tools are used, the work is easy to learn and the tasks can be adapted to the age of the students. Younger students can assemble solar cookers kits. Experience with solar cooker construction courses shows how easy this is for the students.

[46] Seifert, B.: “Kochen mit der Sonne” – Der Parabol-Solarkocher als Instrument der Umweltpädagogik und der nachhaltigen Entwicklung (“Cooking with the sun” - The parabolic solar cooker as an instrument of environmental education and sustainable development)
Download: https://www.ams-forschungsnetzwerk.at/downloadpub/parabol_umwelt_Seifert_Endfassung.pdf

8.2 The SK Solar Cooker as an example of an Open Source Appropriate Technology (OSAT)

Young generations in industrialized countries are finding it increasingly difficult to develop helpful devices of their own to enable them to experience a sense of achievement and to motivate them to rely on their skills and practical abilities and therefore, shape their life in a sustainable way.
This experience cannot be achieved when the lure of a material growth ideology prevails and habits of comfort, disinterest and disempowering consumption dominate. This is incompatible with the effort to save resources of our earth and to deter the consequences that follow.

Uncontrolled consumption is closely linked to a rapid devaluation of the goods consumed. A “consumer society” is inevitably a “throwaway society” continually changing with new fashions and generates needs that constantly devalue the given, i. e. shortness of breath, entertainment and distraction instead of living in harmony with nature.

In developing countries, poverty slows down and prevents the development of a throwaway society, but is also the reason why people there are often oppressed by heavy and unhealthy work. They do not have the necessary tools and their helplessness can-force them to danger and destroy their environment.

There is an urgent need for a worldwide technology that is in the sense of "intermediate technology" as already described by E.F. Schumacher in his famous book “Small is Beautiful - A Study of Economics as if People Mattered”[47].

One example of such an appropriate technique is the parabolic solar cooker:

- It is adapted to people's needs,
- is durable: the grandson should be able to inherit it from his grandfather,
- is fully recyclable,
- is safe,
- is in harmony with resources, does not consume finite energy during operation,
- can be easily repaired,
- is instructive and can be motivating in many ways,
- can be built in communities and is community-enhancing,
- can be used in a variety of ways,
- creates practical experience,
- shows that there are long term and permanent solutions possible,
- is modular and adaptable to the requirements,
- can be creativity stimulating.

When promoting “Appropriate Technology”, however, one can fall into the error of seeing job creation as the primary goal. Local manufacturing, although possible with meager demand of resources, can hamper poverty alleviation. This is best explained by usage of the solar cooker as a "poor people technique" as preferred to powerful, high-quality solar cooker with a long service life.

[47] See subchapter 1.2

8.3 Workshops for cooperation experience

Solar cooker building courses are a community experience. However, work in the community also requires the work of everyone who, in silence, in concentration, learns about the topic, gets involved and develops their own ideas, thinks them through and tries out possibilities and can then work together with others in a well-founded manner. The suggestions in this book are intended to assist with this work as an open source.

The solar cooker offers, in pa rticular, a good basis for this way of teamwork. Its possibilities are easily recognized when thought through and they open a wealth of topics with use of the solar cooker. In the community, the achievements of the group can be discussed and evaluated and afterwards continue work of improvement.

One's own personal work and experience have a high value and they fulfill an important task of social development. Community work should not just be a shallow discussion lacking of in-depth understanding. The results are developments of high quality that are continuously improved within the community.

In the solar cooker program, young people can practice how to produce components from simple semi-finished products by bending and screwing them together. Simple devices and tools are used, the work is easy to learn and the tasks can be adapted to the age of the students. Experience with solar cooker construction courses show how easily students can be motivated through practical work.

Developing devices for “cooking by retained heat” is also a wonderful opportunity for creative work in schools. This technique, which we can call "thermos technology", is still completely underestimated. Approximately half of the fuel requirement can be saved in this way. The thermos technology, like the technology of the firewood-saving stoves, should be promoted with the worldwide school solar cooker program.

Appendix A
Calculation of Reduction of Wood Consumption through Transition to OSAT

Table 1: Calculation of Reduction of Wood Consumption through Transition to OSAT
with improved Stove, Thermos-Technology and Solar Cooker SK14

Consumption of Wood per Household per Year	Unit	Fuelwood traditional	OSAT	Charcoal traditional
Net Calorific Value NCV_Wood (15% Humidity)	MJ/kg	15,6	15,6	
Net Calorific Value NCV_Charcoal	MJ/kg			29,5
Thermal Efficiency η of Stove		**12%**	41%	**20%**
Fuel Consumption per Household per Year (Senegal-Doc.)	kg fuel/year	**4680**	1370	1485
Effective Energy Demand E_eff per Household per Year	MJ/year	8761	8761	8761
Mass Ratio Wood/Charcoal (default value IPCC)	kg/kg			6,00
Percentage of Saving f_thermo via Thermos Technique		45%	45%	45%
Percentage of Saving f_solar via Solar Technique (SK14)		45%	45%	45%
Consumption of Wood per Household per Year			*small sticks*	*branches and stems*
Without Thermos- and Solar Technique	kg wood/year	**4680**	1370	8909
Including Thermos- and Solar Technique	kg wood/year		**414**	

Result: Through transition from traditional cooking to OSAT - Open Source Appropriate Technology (here: Ben-Stove, hay basket, Solar Cooker SK14) annual wood consumption of the household can be reduced from 4680 kg/year to 414 kg/year. Transition from traditional charcoal stove to OSAT enables a reduction of wood consumption (for charcoal production) of 8909 kg/year to 414 kg/year per household.

Table 1 shows a calculation of firewood consumption reduction per household in a developing country by transition to Open Source Appropriate Technology (OSAT), here: an efficient firewood stove e.g., Ben-stove; a thermos basket and flask; a parabolic solar cooker SK14.

Data for traditional firewood consumption and the efficiency of traditional stoves were taken from the UNFCCC publication "ASB0025 Standardized baseline - Cookstoves in Senegal, Version 01.0", submitted to UNFCCC by DNA (Designated National Authority) of Senegal:

> Firewood consumption B_{old} before the transition:
>
> B_{old} = 4.68 tonnes/household/year
>
> Efficiency η
>
> a) Use **0.12** for the efficiency of the pre-project device for woody biomass stove replacement projects:
>
> b) Use **0.20** for the efficiency of the pre-project device for charcoal stove replacement projects.

The effective energy requirement E_{eff} of the household can be calculated from the data for woody biomass stove, with the Net Calorific Value of wood NCV_{wood} = 15,6 MJ/kg and the proposed efficiency η_{Wood} = 0.12:

$$E_{eff} = B_{old} * NCV_{Wood} * \eta_{Wood}.$$

This calculated effective energy requirement E_{eff} = 8761 MJ/year is also assumed for a household that cooks with charcoal or uses the OSAT. In this way, the firewood savings can be plausibly calculated. When replacing charcoal, the corresponding charcoal requirement B_{cc} is first calculated with efficiency η_{cc} = 0.20 recommended under b) and Net Calorific Value of charcoal NCV_{cc} = 29,5 MJ/kg:

$$B_{cc} = E_{eff} / NCV_{cc} / \eta_{cc}$$

With the default value for converting the required amount of wood in the kiln for charcoal production (factor f_{bc} = 6 according to IPCC Guidelines for National Greenhouse Gas Inventories, Revised 1996, Ref. Manual p. 1.45), the corresponding amount of wood for traditional charcoal consumption is calculated:

$$B_{oldcc} = B_{cc} * f_{bc} = 1485 \text{ kg/household/year} * 6 = 8909 \text{ kg/household/year}.$$

This simple approach can be justified as conservative by the fact that the carbon content of the wood stacked in the kiln is converted into CO_2 and into carbon compounds with a higher Global Warming Potential (GWP) during processing and later thermal use.

In **TABLE 1**, it was assumed that both thermos technology and solar technology can reduce wood consumption by f = 45% in each case. The remaining amount of wood B_{new} is calculated with the factor $(1 - f_{therm}) * (1 - f_{solar})$. The factors adapted to the local conditions can differ greatly from this. For conditions according to Photo 1.2, f_{solar} may approach 100% (no other energy sources than solar energy needed).

The very low remaining wood consumption needed thanks to OSAT can be sustainably supplied by annual-harvesting of regrown small sticks. Therefore, CO_2 emissions arising during their combustion may be completely neglected.

Appendix B
Calculation of CO_2-Emission Reduction through Transition to OSAT with improved Stove, Thermos-Technology and Solar Cooker SK14

Table 2: Calculation of CO2-Emission Reduction through Transition to OSAT with improved Stove, Thermos-Technology and Solar Cooker SK14

Saving of CO2-Emission from Transition to OSAT (here: Ben Stove, Thermos- and Solar Technique SK14)	Unit	from trad.Fuelwood	to OSAT	from trad.Charcoal
Consumption of Wood per Household per Year			*small sticks*	*branches and stems*
Without Thermos- and Solar Technique (s. Table 1)	kg wood/year	**4680**	1370	**8909**
Including Thermos- and Solar Technique (SK14)	kg wood/year		414	
Emission Factor EF Wood (IPCC 2006)	kg CO2/MJ	0,112		0,112
Net Calorific Value NCV Wood (UNFCCC default value)	MJ/kg wood	15,60		15,60
Emission Factor EF_mass	kg CO2/kg wood	1,747		1,747
Fraction fNRB of non-renewable biomass		0,85		0,85
Emission Factor EF_mass_NRB	kg CO2/kg wood	1,485		1,485
Reduction Wood Consumption through Transition to OSAT	kg wood/year	4266		8495
Saved CO2-Emission per Household per Year	kg CO2/year	**6335**		**12616**

Result: Transition from traditional cooking with fuelwood to OSAT saves about 6 tonnes CO2-emission per household per year.
Transition from traditional charcoal stove to OSAT enables a CO2-emission reduction of about 12 tonnes per household.per year.

It is assumed that only a proportion of f_{NRB} = 85% of the consumed wood can be considered as non-renewable. UNFCCC a factor f_{NRB} = 0.85 or higher for many countries. Therefore, the applied effective emission factor is: $EF_{mass,NRB}$ = 0.112 kg CO_2 /MJ * 15.6 MJ/kg wood * 0.85 = 1.485 kg CO_2 /kg wood. This factor is used to multiply the firewood savings from table 1 when switching to OSAT equipment in the household.

TABLE 2 shows the savings in CO_2 emissions resulting from the transition to OSAT. For this purpose, the savings values from **TABLE 1** are converted into emission values. The conversion is based on the emission factor[48] of wood EF = 112 tonnes CO_2/TJ = 0.112 kg CO_2/MJ, which is related to the NCV value of wood (15.6 MJ/kg).

This results in a conversion factor of 1.747 kg CO_2/kg Wood. It is assumed that only a proportion of f_{NRB} = 85% of the wood can be regarded as non-renewable. A factor f_{NRB} = 0.85 or greater is given by the UNFCCC (United Nations Framework Convention on Climate Change) on the Internet[49] for many countries. The emission factor is therefore

$$EF_{mass\_NRB} = 0.112 \text{ kg } CO_2/\text{MJ} * 15{,}6 \text{ MJ/kg Wood} * 0.85 = 1.485 \text{ kg } CO_2/\text{kg Wood.}$$

This factor is used to multiply the wood savings from **TABLE 1** when switching over to OSAT equipment in the household. This results in a CO_2 saving of approx. 6 tonnes of CO_2 per household and year when switching from traditional firewood or 12 tonnes of CO_2 per household and year when switching from traditional charcoal use to OSAT.

It may be objected that the woody biomass consumption of 4.68 tonnes / household / year mentioned for Senegal is not reached in arid regions. The cause lies in the so-called "suppressed demand" (SD); the use of the Senegal value is nevertheless appropriate. The suppressed demand was recommended as creditable by the UNFCCC-workshop:
https://cdm.unfccc.int/methodologies/Workshops/cdm_standards/s3_wb.pdf

48 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 2.5 (cont.) p. 2.23
49 https://cdm.unfccc.int/DNA/fNRB/index.html

The approach used here corresponds to the procedure described in the UNFCCC workshop:
“Define minimum standard level based on literature
– Convert this to emissions by identifying baseline technology
– This then eliminates the need to monitor baseline while providing reasonable, objective baseline.”[50]

Appendix C
Estimations about Financing OSAT Household Energy Equipment

Table 3: Estimations about Financing Household Energy Equipment (OSAT)		
Production and dissemination of the equipment by local branches of Innovation Institutes		
(Assumed values for estimates)		
HH = household		
Household energy equipment costs for a), b), c), d):		
a) Cost of locally produced efficient fuelwood stove (e.g. Ben-Stove) with workspace	30	€
b) Cost of hay basket and thermos flask	30	€
c) Cost of high quality solar cooker (SK14)	140	€
d) Cost PV panel and 3 LED lamps	100	€
Investment K_Eq for energy equipment per household (HH) for a), b), c), d)	300	€
Amortization period t_A	5	year
Repaiment k_Eq = K_E / t_A per HH and year through Innovation Institute	60	€/year
Interest and additional project costs (supporting HH for maintenance)	60	€/year
Dept service k_Dept = k_Eq + k_Interest of the Innovation Institute	120	€/year
Accounted amount of CO2_eq emission reduction for investment per household per year	4	tonne CO2/year
Price of certificate per tonne CO2_eq	30	€/tonne CO2
Income of Innovation Institute per household-equipment per year through certificates (= k_Inst)	120	€/year
Responsibility for maintenance by owner of the equipment; supervision by Innovation Institute		
Income of the Innovation Institute over a longer period of time (e.g. 10 years) through the certificates received annually		

Table 3 contains data on the supply of households in developing countries with Open Source Appropriate Technology (OSAT). Deviating from the usual projects to reduce emissions through improved stove technology, it is proposed to equip households in such a way that energy poverty is comprehensively overcome.

It is therefore recommended to equip households with LED lamps and a PV charging station, too. The reduction in CO_2 emissions that can be achieved with this is, however, small in comparison with the savings calculated in Tables 1 and 2. For projects in the context of offsetting greenhouse gas emissions, however, this has the advantage that the urgently needed way out of poverty is effectively paved through high acceptance.

The table contains rough estimates about the costs for the switch to OSAT-equipment of poor households. The recommended OSAT household energy equipment consists of:

a) locally produced efficient fuelwood stove (e. g. Ben-stove)
b) hay basket and thermos flask
c) highly effective and durable solar cooker (SK14)
d) PV-system with LED lamps.

[50] https://cdm.unfccc.int/methodologies/Workshops/cdm_standards/s3_wb.pdf

The estimated costs result in the sum K_E = 300 euros. The service life of the equipment should be well over 5 years. If an amortization period of 5 years is assumed, the repayment is k_{Eq} = 300/5 euros/year. For the annual debt service, repayment and interest are added. There are also costs for project support.

It is assumed that the maintenance of the equipment and the participation in the planting of shrubs to be harvested annually for the fuel (see **TABLE 1** in Appendix A) is carried out by the household, which is contractually obliged to do so. Supervision is carried out by the Innovation Institute.

The generation of certificates assumed in the lower lines of the table is conservative data. The result is a balance of costs and income (both 120 euros/year). In Appendix B (**TABLE 2**, bottom line), annual CO_2 savings of 6 to 12 tonnes per household and year were calculated, whereby the emission savings through the PV lights (especially when replacing petroleum) are not taken into account.

It can be assumed in favor of the host country that it will be credited with the surplus certificates for the entire duration of the project. This duration should be at least 10 years.

Appendix D
Notes on Fireless Cooking - Cooking with Retained Heat[51]

In her book "Fireless Cookery"[52], Heidi Kirschner reports experiences and recommendations on cooking with retained heat. The book is unfortunately out of print. Here notes from the German edition of the book and from personal experience with this advantageous technology are compiled.

The principle of fireless cooking is very simple: The food is pre-cooked on a stove or with a solar cooker and then the pot, well-sealed with a lid, is placed in an insulating environment for finishing the cooking and for keeping it warm. Thus, the heat storage mainly is done in the food and its temperature can be maintained for several hours above 80 °C, so that even meals which require a long cooking time can be cooked. The insulating container (fireless cooker, insulated box; hay box, hay basket, wonderbag, wonderbox) is equipped with an insulation that surrounds the pot and ensures low heat loss. This technique has a long tradition. For more than hundred years hay boxes are known.

The technique of fireless cooking is also suitable for dissemination of Appropriate Technology in developing countries, because of the insulating box can be completely manufactured in these countries with locally available resources. The websites of Practical Action[53] and Solar Cookers International[54] contain information about Appropriate Technology, including fireless cooking.

1. Safety Precautions for Fireless Cooking

To avoid burns, the hot pot is to touch with potholders. One danger is the fact that the lid and the pot handle become very hot in the insulated box, so be sure to touch them with potholders.

A good stability of the pot in the insulating container is necessary. This condition is well satisfied of baskets and other stable containers. On the other hand, a bag is less stable.

Heidi Kirschner writes under "Safety Precautions": *"When cooking meat (including poultry) or fish you should always be extra careful. If it is frozen product, you should make sure that they are completely thawed before cooking. The United States Department of Health has found that in the preparation of these foods a safety temperature of 63 °C must be maintained in order not to take the risk of an ordinary household food poisoning. When cooking in the cooking box, the temperature drops very slowly, and I have checked numerous times (using different foods and pot sizes) that the food remained piping hot up to four hours - often much longer - and that the temperature was 63 °C or more. If you have a thermometer, you should convince yourself. If you want to let a pot once more inside the box or if you suspect that food is cooled, then just let it boil again and simmer for 5 minutes, so that you can be absolutely sure that nothing may be lost. Dishes that were longer than 24 hours forgotten in the cooking box, you should throw away."* (translated from the German edition[55]):

---

[51] Excerpt from the article of the same title by I. and D. Seifert, published on the website of Solar Cookers International: https://solarcooking.fandom.com/wiki/Heat-retention_cooking
[52] H. Kirschner: Fireless Cookery. Madrona Publishers, Seattle (1981)
[53] https://practicalaction.org/
[54] https://www.solarcookers.org/
[55] "Die gute alte Kochkiste – Eine alte energiesparende Kochmethode – neu entdeckt", Verlag Zweitausendeins, (1984)

The risk of food poisoning exists therefore especially if dishes were poured from the pot and the rest is kept warm, but when it is already cooled below 63 °C. Therefore, the remainder has to be boiled again.

2. Design of "hay boxes"

The smaller the pot and the pot content, the better it must be insulated. A water volume of 10 liters in a 12-liter pot can be hold at temperatures above 80 °C with simple blankets in a basket for many hours. A 2-liter pot needs better insulation, preferably with pillows and the transfer to the insulated container must be particularly fast to avoid heat loss. For small amounts (up to about 1 liter) thermos flasks (A4) with highly insulating effect (by vacuum and radiation reflection) are probably the most appropriate solution.

Provisional arrangements have the disadvantage that they usually lose their effect after a short time or have an unpleasant aspect. It should also be ensured that the handling is convenient. The insulation material should not be used loosely, but e.g. be used as a filling for pillows. This also has the advantage that the insulating pillows after use can be easily taken out and dried. Moisture reduces the insulating effect.

The insulation should avoid any air gaps, as heat would be dissipated through the air convection. Therefore, the cushions are closely packed together and possibly held together with a cloth or blanket. For the lateral insulation of the pot a long cushion is advantageous (Figure A1).

3. Insulation Material

A variety of insulating material is available. There are the usual cushion fillings: wool, cotton, hay, straw, corn husks, cork, but also synthetic fibers or polystyrene foam beads. For workarounds shredded paper would be suitable. Earlier "hay boxes" usually used not only hay, but also sawdust or chipped wood as insulation material. It was covered with a cloth providing a suitable hollow for the pot. Insulations which cannot adapt to the pot form (e.g. rigid foam insulation), have the disadvantage that they cannot be used for different pots.

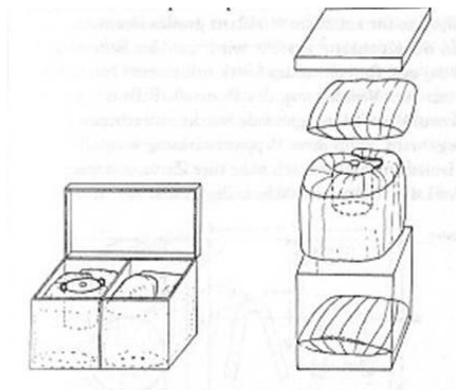


Figure A1: Drawing in the book of Heidi Kirschner

4. Coating of the Insulating Material

As a pillowcase cotton fabric is especially suitable because it can well withstand the temperature of 100 °C. Plastic film of polyethylene etc. is not suitable because it would stick at the pot.

5. Suitable Containers

Several containers are suitable: a chest (photo A1), a basket (photo A3), but also a bag. A stiff cardboard, possible with film coating, if properly cared can be quite durable. Bags are in use, often with polystyrene foam beads as insulating material. The insulating material is included between the outer and the inner shell of the bag. Tightly woven baskets of straw (photo A4) are stable and have additional insulating effect.

A special insulating material is expanded polypropylene, as in use for commercial pizza-transport and as it is realized in the “Wonderbox” of the Save80-cooking system. This efficient insulating material is so strong and durable that no separate container is required. A piece of paper or cardboard under the bottom of the pot should prevent the pot from sticking to the insulation.

It may not be quite understandable that a basket can be used as container for the pillows or blankets, because it is not leak proof. But it is essential that the insulation is kept in shape and the pot is fixed reliable in the interior and is kept warm by the insulating material. The insulation should be as dry as possible and should be dried well after use. Thus, pillows or blankets should not be attached to the basket, so that they can be taken out for drying.

6. Dealing with Soot-Blackened Pots

If the pot is blackened with soot from cooking on a stove, then you should ensure that it doesn’t pollute the insulation. The pot must be quickly inserted into the insulating environment, so that a previous cleaning of the pot is not possible. Therefore, an extra bag is recommended which covers the pot. Provisionally instead of the bag sheets of newspaper may be used, but it can be expected that the carbon black trickles out. Therefore, a large paper bag or an easy-to-clean cloth would be preferable.

7. Pots and Lids

The lid should close the pot as tight as possible, to avoid that escaping steam humidifies the insulation, thereby reducing the insulating effect.

From Heidi Kirschner is recommended that the pot is always filled up to two thirds or to about 5 cm below the rim. This is especially true for food, but with water the pot be filled up so far that the water will not spill out when the pot is handled.

8. Installation Location

To insert the hot pot, the container should be right next to the furnace in order to avoid cooling of the pot, which is fast at high temperature. Then the insulated container with the pot can be transferred carefully to another place.

9. Applications of Fireless Cooking

The book by Heidi Kirschner describes a variety of dishes, but the abundance of applications is not exhausted. It is recommended that an interactive cookery book is provided in the internet and the dissemination of experience is organized.

In most applications, the principle is always to replace the "simmering" on the stove by cooking in the insulated container. It also avoids the subsequent warm-keeping, so that food or water needs not to be heated again. The simmering on the stove after boiling is reduced to a short time. In the book by Heidi Kirschner a period of 3 to 15 minutes (depending on the dish) for the remaining simmering is mentioned in the recipes. Usually, a pot with about 3.5-liter capacity is assumed. If large quantities are cooked in correspondingly larger pots the duration of the simmering on the stove is less. Keeping warm is particularly advantageous if it avoids to light a fire again, because that can be quite laborious.

In some countries, beans are very cheap, but they are not cooked, because the cost of fuel is high and the hours of cooking cause headaches. But even large beans can be soft boiled in the isolated container (after short precooking) without energy consumption and without supervision. The beans should be soaked at night, then precooked with about 5 liters of fresh water and then finished in about 4 hours in the fireless cooker without consumption of fuel and without inhaling of exhaust.

In her book Heidi Kirschner suggests that food which only require short cooking time or which is cooked with little water, are not suitable for fireless cooking. For pasta which tends to stick, the cooking with retained heat may not be suitable.

10. Combined Fireless Cooking with the Solar Cooker

Cooking with retained heat refutes the main argument against solar cooking in developing countries: “People come in the evening of the field work and need to cook when the sun is down”. On the contrary, the cooked and hot held food must be cooked not only on the often primitive and unhealthy and environmentally harmful fire, there is no fuel required and the food is immediately ready on returning home from the field. Of course, it is necessary that a cook has prepared the meal, as it has been customary in all countries in former times, as especially the grandmothers took over this task, also caring of the infants.

If you use solar box cookers, the box can also be applied in principle for keeping warm, as the reflector is folded onto the glass. However, the box is blocked for further solar cooking and the heat-insulating effect is generally lower than in a special insulated container.

11. Benefits of the Technique of Cooking with Retained Heat

Cooking with retained heat relieves from long cooking on the stove, because simmering is almost completely eliminated. There is no supervision necessary because the food in the container cannot burn or boil over. Later arriving participants find a hot meal. Restart of fire is avoided. Fuel consumption and emissions are prevented.

Even with the supply of larger groups the technique of cooking with retained heat is useful. An example: At a meeting of SOS Children's Village mothers in Caldonazzo, Imma Seifert was invited to demonstrate the parabolic solar cooker; she had cooked a large pot of goulash for lunch. However, the meal was delayed until midnight, but the pot in the hay basket was still hot, much to the amazement and enthusiasm of the participants.

With the heat retaining technique water can be kept hot for a long time; especially if you have a large pot of boiling water (e.g. 8 liter), for example, from the solar cooker. You can keep the water hot overnight. The hot water can also shorten the cooking time, because one already starts at a high temperature.

Cooking with retained heat is still far from being exhausted and it is a wide field for appropriate solutions. This technique can be combined with all conventional cooking techniques and saves about half of the energy previously used for cooking.

The smoke in the kitchen (“killer in the kitchen”) is the fourth main cause of death worldwide. Cooking with retained heat produces no fumes, thus avoiding completely the smoke exposure, with the traditional three-stone fires or other stoves without chimney occur during hours of simmering.

12. Photos of Examples for the Thermos-Technology

Photo A1: Simple chest with pillows and blanket

Photo A3: Parabolic solar cooker with thermos basket

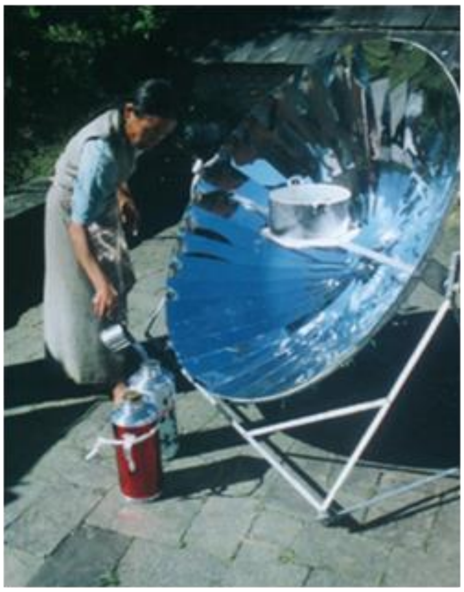


Photo A2: Thermos flasks in combination to the parabolic solar cooker (courtesy K. Schulte: SK14-Project Solar Cookers for Nepal, Rotary Sweden)

Photo A4: Straw basket (Source: Courtesy Jagadeeswara Reddy, NEDCAP, India)

DIE GUTE ALTE KOCHKISTE

von Heidi Kirschner

Eine alte energiesparende Kochmethode – neu entdeckt
Mit Rezepten

Zweitausendeins

Deutsch von Ulla Neckenauer.

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Appendix E
Advice by Imma Seifert from almost 40 Years of Experience with the Parabolic Solar Cooker

Since the beginning of 1984, Imma Seifert has accompanied the development of the parabolic solar cookers of the SK design with words and practical experience. She wrote the brochure "Solar cooking with the parabolic cooker", which is freely available to all on the Internet[56].

Imma Seifert developed many helpful and everyday applications, e. g. baking of bread and cakes for the parabolic solar cooker. At 12 annual meetings (Encuentros Solares) of the Fundación Terra, she baked solar cakes for the approximately 400 participants as well as giving the participants cooking demonstrations (see photo E1).

Photo E1: Solar baked cakes at Encuentro Solar in Bencarló / Spain

She points out that when cooking with the solar cooker of the SK design, the usual recipes can be retained if certain rules and recommendations are observed. These rules and recommendations should be discussed with the following proposals for the project week and tried out with practical examples.

The experience was primarily gained with the large parabolic solar cooker (1.4 m reflector diameter). The same rules apply to smaller SK-type solar cookers (e.g. school solar cookers). But the pot size has to be adapted to the reflector diameter (e.g. 3-liter-pot for the 1-meter-reflector).
In the course of a project week, she gives the following practical recommendations and safety rules. The rules are well thought out and tested, but liability for damage of any kind is excluded.

Project week with the parabolic solar cooker with solar cook Imma Seifert

FIRST DAY

Why solar cooking should spread worldwide

Many families in Africa, South America, India and other countries use a three-stone fireplace, i.e. an open fire, for cooking. The pot stands on three large stones or a brick ring that is open at the front and is heated with firewood. Firewood used to be easy to get. There were enough dead branches on the surrounding trees, but people destroyed and continue to destroy a large part of the tree population. There is a depressing firewood crisis in many regions. This means more and more efforts to find firewood. Even children are often busy for several hours a day with the collection of wood. They cannot then go to school and are exposed to many dangers. Added to this is the burden they have to carry. If you have enough money, you can buy firewood at the market. However, since many people are too poor to buy enough food, they have no money left over for firewood. Often the wood is more expensive than the food. When the mother cooks on an open fire, the children also inhale

[56] https://eg-solar.de/wp-content/uploads/2016/04/Parabolic_solar_cookbook_-_Imma_Seifert.pdf

the smoke and exhaust gases, which seriously damage their lungs. The eyes are also affected because the smoke burns and damages the eyes.

Solar cooking and thermos technology offer a welcome way out of the oppressive harm and dangers of cooking on an open fire. But there are many more reasons for the spread of solar cooking. In the project week, we want to show a wide range of opportunities, including for households in industrialized countries. Here, too, the transition to renewable energy sources is urgently needed.

Basic rules to be observed when cooking with the parabolic solar cooker

(1) We must not leave children unsupervised with the solar cooker.

(2) The solar cooker needs a sunny, flat, sheltered place. We can improve stability against gusts of wind by placing a bucket of sand or stones or a watering can on one side of the base frame.

(3) We only use pots that stand securely in the pot support. Cast iron or cast aluminum pots or the large black, enameled solar cooking pot with a diameter of 28 cm and a capacity of 10 or 12 liters are very suitable even for larger households with the cooker with a reflector diameter of 1.4 meter. The pot size should be adjusted in case of smaller reflector diameters.

(4) For baking bread and cakes, I prefer a black cast aluminum pot with a diameter of 28 cm and a height of only 13 cm. When baking with this lower pot a nice crust is formed. We will learn this on the fourth day.

(5) A pan with a high rim is advantageous for stir-fries. A wok is also suitable. With ceramic pots, the poor heat conduction of the ceramic is disadvantageous and cracks can occur in the material.

(6) We don't stand in the sun unless absolutely necessary. In order to reach the pot safely, we always swing the reflector so that we are standing in the shadow of the reflector next to the pot support (see photo E9)

(7) The pot and the pot lid become very hot due to the sun's rays. We use oven clothes when we touch these parts! But don't leave the oven clothes on the lid or on the pot support; they might burn.

(8) Combustible material (e. g. newspaper) can be ignited in the area where the incoming radiation is concentrated.

(9) There must be no parts in the area of the concentrated radiation that are not heat-resistant (e. g. plastic or wooden handles). If you cannot unscrew these parts, you should wrap them in aluminum foil.

(10) We avoid dazzling! Sunglasses do not protect against direct or reflected solar radiation. It is essential that dazzling is avoided by handling the solar cooker correctly (see below). Do not use small pots as they will not fully absorb the concentrated radiation.

In all applications of the solar cooker and in the manufacture and storage, it is urgently necessary to avoid possible dangers. This applies in particular to the concentration of solar radiation outside the reflector when the solar cooker is not in use. Then the reflector is to be brought into the resting position, i.e. with the curvature upwards.

How do I avoid being dazzled from the solar cooker?

a) To insert the pot (of sufficient size) into the solar cooker and to remove it, we always swing the reflector so that the reflector shields the sun (see photo E9). Then no solar radiation falls into the reflector and we can insert and remove the pot in the shade at a comfortable distance from the pot support.

b) We do not look into the reflector when there is no pot in the solar cooker and the reflector is not oriented to the sun.

c) We orient the solar cooker to the sun using the shadow indicator. It is advisable to look afterwards at the illuminated pot. Part of the radiation is reflected there and produces white “sun flames”. These should cover the lower part of the pot in particular (Photo E7). Then the upper part of the pot and the pot lid are less illuminated. We should re-orient the stove to the sun every 15 to 20 minutes by turning the whole stove a bit and tilting the reflector until the shadow of the indicator is again centered or the "sun flames" again cover the bottom of the pot.

d) Only dark parts may be in the area of concentrated radiation because bright or reflective parts cause glare. We blacken shiny parts in the pot area with black stovepipe paint, see e.g. photo E7.

e) The reflector must not be deformed. If the shape of the reflector sheets is not correct, then the solar radiation is not reflected to the pot and cannot be converted into heat by it.

f) If the above rules are followed and the reflector is oriented to the sun, then we can approach the pot from the front and we will not be dazzled. The pot shields us from the concentrated radiation. We can then e. g. add spices to the pot.

g) For longer stirring or for tasting, we swivel the reflector in such a way that no solar radiation falls into the reflector and we can easily approach the pot (Photo E9).

h) Food that needs to be stirred for a long time should not be prepared with the solar cooker. But ways can be found to avoid this tedious stirring, most notably by using the thermos technique (when cooking corn porridge, for example).

i) Whenever the cooker is not in use, it remains in the resting position, i.e. with the curvature of the reflector pointing upwards (Photo E10).

Safety precautions when storing the solar cooker

If the reflector is not well oriented to the sun or not in its resting position, there is a risk that incident solar radiation will be concentrated by the reflector onto an object in the immediate vicinity and damage it with the heat or even ignite easily flammable material. However, despite many attempts, we did not succeed in igniting something outside the focal area.

When we disassemble the stove, we should not keep the reflector outside. You can hang it decoratively on a wall (see photo E11), whereby there must be no gap to the wall through which the sun can shine.

Rules for maintaining the solar cooker

Our cooker is outside all year round for more than 12 years. When not in use, the reflector is in the resting position (curvature upwards, photo E10). Cleaning the cooker is very easy. We use soft, lint-free cloths or sponges. First, the reflector is washed with a wet cloth or sponge soaked in washing-up liquid. Then we rinse the reflector plates with water and dry them with a soft cloth or newspaper. You can injure yourself on the edges of the reflector sheets, e. g. when cleaning. Pay attention to this when washing and drying the reflector. Never use any metal scourers or cleaners with scouring powder on the reflector!

Photo E2: Boiling water for its sterilization is an enormous task worldwide. Photo from a course at Muni Sewa Ashram / India

Example: Boil water

Boiling water with the solar cooker is particularly easy. My solar cooker is in the garden in a sunny, paved, wind-protected spot. It is in the resting position, when not in use. A filled watering can on the base of the solar cooker stand protects my cooker against being knocked over by the wind. In case strong winds or storms are feared, the solar cooker is stored safely or placed on the ground with the reflective side down.

First, I align the solar cooker frame. This means that the base frame must be oriented to the sun in such a way that the two side stands cast their shadows in the extension of the side base frame. Then I turn the reflector so that the curvature faces the sun so that I can place the pot on the pot support in the shade. In my experience, a well filled black cooking pot with diameter 28 cm and with well-fitting lid is particularly suitable for boiling water with the reflector of 1.4 m diameter.

Now I swing the reflector to the sun and use the shadow indicator. But then I make sure that the “sun flames” envelop the pot as far as possible from below. Then the sun's rays are concentrated on the pot area that is touched by the water on the inside of the pot, see e.g. photo E2. We should ensure that the "sun flames" do not appear too much on the pot lid, but mainly on the bottom part of the pot and also a little in front of the pot. We therefore do not have to align the reflector exactly, but, if necessary, set it a little steeper and observe the "sun flames" at the same time.

From now on I turn the base frame every 20 to 30 minutes to follow the sun. I also always adjust the inclination of the reflector a bit. The screws of the reflector's friction clutches must be carefully tightened. Then the reflector remains in the position in which you let go of it. You no longer have to tighten or loosen the screws.

With the solar cooker with a diameter of 1.4 meters I can boil 6 liters of water in one hour with good sunshine. In the International Solar Cooker Test in Almería 48 liters of water were boiled in one day with the 1.4-meter reflector cooker (see chapter 4.3).

Hot water can be advantageously stored in thermos flasks, see photo A2.

We make sure that when cooking, only the solar cooker is in the sun. Alignment of the reflector towards the sun only takes a few seconds with a little practice.

When I want to remove the pot, I turn the stove again so that the curvature faces the sun. In this way I can easily remove the pot and stand in the shade (photo E8).

SECOND DAY

If cooking takes too long, it can be due to the following reasons:

- There is no clear sunshine. This is shown by the fact that the sun does not cast sharp shadows.
- The cooker is not protected from the wind. Wind can carry away a lot of heat. Heat loss from wind can be reduced by placing the pot in a heat-resistant glass bowl with a lid. But a windbreak is better.
- The reflector is not correctly aligned to the sun, i. e. the "sun flames" do not include the lower part of the pot where the food is to be heated.
- The pot lid is missing or the pot is not black.
- The pot size is not adapted to the content.
- Shadows fall in the reflector.
- The reflector plates are dull or dirty.

Example: Cook vegetable soup

We put the pot of water in the solar cooker, which we orient towards the sun. Until the water boils, we can wash, clean and chop the vegetables for the soup. After an hour, when the water is bubbling, we put the hot pot in the thermos basket. So, we always have hot water available. Now we put some oil in another pot (also black and with 28 cm diameter), let it heat up in the solar cooker and add finely chopped onions. When they are translucent, add the finely chopped soup vegetables and herbs. We pour everything with the available hot water and let the whole contend cook until the vegetables are soft. This will take approximately 20 to 30 minutes. Of course, we keep turning our solar cooker to follow the sun. Then we season the soup with salt and pepper and put it in the thermos basket until ready to eat.

THIRD DAY

Example: Boil or bake potatoes

Potatoes can simply be put on with cold water and brought to the boil. The cooking time depends on the size of the potatoes, it can be shortened by dividing them.

Unpeeled potatoes can be prepared (baked) without water in a solar cooking pot in a baking insert (see rules for baking). You can season the well washed potatoes beforehand with olive oil, salt and pepper. The baking time can take one to two hours.

Photo E3: Baking potatoes without water

FOURTH DAY

Rules for baking with the solar cooker

1. For baking, a baking tin (e. g. 26 cm diameter baking mold) is placed in the pot. Do not put water in the pot! Do not place the baking tin directly on the bottom of the pot, but on a distance holder (a wire frame, a tripod or an aluminum wire helix).

Photo E4: Baking a cake

2. Close the pot with the black lid. A glass lid acts like a magnifying glass and can cause black spots on the cake. Bake with the lid closed! A few minutes before the end of baking, push the lid two fingers to the side so that the steam can escape and a crust forms. I found out that a low iron pot with a baking mold insert of 26 cm diameter on a spacer is ideal for baking.

3. When baking, the pot is turned a quarter of a turn every 10 to 20 minutes so that the baked goods in the pot are evenly browned on all sides.

4. Be sure to use oven clothes when removing the baking tin! The pot, the lid and the contents can get very hot. It's a good idea to bend a double wire hook for the baking tin to make it easier to remove. You can also remove the baking tin from the pot with pliers.

Example: Solar baked cake or bread

We can find the instructions for making the cake or bread dough in a baking recipe book. Instead of an oven, we have the solar cooker, the black pot with a well-fitting lid (no glass lid) and the baking tin on the stand. With good sunshine we reach the required baking temperature. For baking cakes or bread, the rules described above must be observed. It is particularly important to use the baking mold on a spacer to avoid burnt spots.

FIFTH DAY

The solar cooker and the heat retaining basket (thermos basket) for cooking with retained heat

Thermos containers are very important for successful solar cooking. Even in the days of our grandmothers and great-grandmothers, heat retaining boxes (“cooking boxes”, “hay boxes”) were in use. It's one of the simplest and most effective ways to save energy and simplify cooking.

If we prepare our dishes with thermos baskets and keep them warm, we can shorten the cooking time in the solar cooker. The dishes cook in the basket without supervision and above all they make cooking independent of the mealtime. The thermos basket saves hours of simmering on an open fire. If there are several baskets, we can serve a menu in several pots. I use thermos baskets lined with blankets and pillows. A basket has the advantage over a wooden box with fixed insulation that the insulation does not get as damp, dries more easily and can be washed.

For example, we can boil dry beans that have been soaked overnight in a solar cooker with plenty of fresh water. When the water boils, we take the pot out of the cooker and put it in the thermos basket. We leave the beans there for 3 to 4 hours. After this cooking time, the beans will be soft. In the meantime, we can use the solar cooker for other uses. If you have a small solar cooker that boils less than 3 liters of water, we recommend using a thermos flask.

Example: Cooking rice in a thermos basket

When cooking rice, I can use hot water that I preferably boiled in the morning and stored in the thermos basket. I take two cups of hot water for each cup of rice in a suitable pot (see photo E5), boil the contents briefly and put them in the thermos basket. The cooker is thus ready for the next dish. The rice is cooked in the thermos basket in 30 to 40 minutes.

Photo E5: Cooking rice in a thermos basket

SIXTH DAY

Rules for frying and roasting

Frying and roasting requires high temperatures, which can be reached with the parabolic solar cooker when the sunshine is good. However, rules must be observed, especially to avoid heat loss.

1. When deep-frying in hot cooking oil (e. g. baking donuts), only fill the pot up a few centimeters.
2. Put the lid on loosely to reach the required temperature and avoid grease splashes on the reflector.
3. For frying, it is advantageous to use a pan with a high edge (photo E6).
4. Wear sunglasses when frying bright dishes (fried eggs, fish, tortilla, etc.).
5. Do not toast in the enamel pot, because the enamel layer can chip off the bottom of the pot at the high temperatures that occur.

Photo E6: Frying tortilla

SEVENTH DAY

Example: Preserving vegetables and fruits

For this we need a pot in which we can put mason jars (photo E7). We wash the mason jars including their caps with hot water. We brought the washing water to a boil in the solar cooker beforehand. As an example, we will use the preserving of cherries. First, we cook the brew in the solar cooker. For this we need for 3 glasses (each with a capacity of 1 liter), 3/4 liter of water, 1 stick of cinnamon, 2 cloves, 600 g of sugar.

Photo E7: Preserving fruits and vegetables. A glass lid should be used.

Wash, dry, stem and stone the cherries. Bring the water with the sugar, cloves and cinnamon stick to a boil in a black saucepan in the solar cooker. Add the cherries and bring to the boil again. Strain the cherries and pour into the prepared glasses. Pour the liquid over it and close the jars properly. Boil the compote in a water bath in the solar pot in the solar cooker for another 30 minutes. When bubbles appear in the jars, the conservation of the cherries is done.

Example: Obtain fruit juice with a steam juicer in the solar cooker

Photo E8: Steam juicer heated by the solar cooker

With a commercially available steam juicer, a source of income can be developed with the solar cooker without any disadvantageous energy consumption. There are also steam juicers with electric heating, but they use a lot of electricity. The steam juicer should be black. If this is not the case, we should paint the bottom pot, which contains the water for juicing, with stovepipe black paint (see photo E8). We fill the perforated insert of the steam juicer completely with the prepared fruit. We add the sugar. We fill the bottom pot insert with water and place the steam juicer on the solar cooker.

We align the reflector with the sun and adjust it every 20 minutes. After an hour, the filling tube will fill with juice. Now we can place the bottle in a bowl and let the liquid drain into the bottle by opening the clamp. We let the sealed bottles cool down after bottling.

We can also use the overcooked fruit puree to make jam or fruit slices, depending on the type of fruit. If we boil the fruit juice with jam sugar, we can make a jelly out of it.

Photo E9: Operating the pot in the shadow of the reflector

Photos E10: Safety position (resting position) when the solar cooker is not in use

Photo E11: Solar cooker K10 storing at wall (reflector diameter 1 meter)

Photo E12: "Each student should build their own solar cooker". This is made possible, for example, by prefabricated kits for parabolic solar cookers with a reflector diameter of 1 meter (ESCOLAR 10) or the shown cooker with 80 cm (ESCOLAR 8)

What I am very concerned about

If I can experience in the garden with my solar cooker how the dishes are made with solar energy, then I wish with all my heart that all women, not least the women in developing countries, have the same opportunity. How laborious and dangerous it is to collect the wood for the meal in the regions affected by the firewood crisis. In some places there is only undergrowth, or smoking grass is being burned. Currently two billion people do not have enough firewood for cooking and for many now the fuel under the pot is more expensive than the contents.

Photo E13: Two of my grandchildren with a cooker of 50 cm reflector size (K5)

They used to be able to collect the wood for free. The only thing they have in abundance is solar energy.

I always feel deeply concerned when I see pictures of women cooking on the ground in dust and smoke. They too deserve a decent job and how easy it would be to help these people. A visitor from South America who saw the solar cooker enthusiastically exclaimed: "Father Sun is now cooking for us because Mother Earth has run out of firewood for us".

Fortunately, solar cooking is spreading at an accelerating rate. More and more people are getting involved. The many advantages of the solar cooker also contribute to its success, e. g. the high performance of the cooker, which is obtained from morning to evening and which can fulfill almost all tasks.

In industrialized countries, too, solar cooking also offers wonderful possibilities: Everyone will experience that the solar cooker makes them more nature-loving, more environmentally conscious and freer. I wish you the pleasant experience of a simple way of cooking that does not consume any resources, that is independent of supplies, that is in harmony with nature and therefore helps to maintain good living conditions for our children and grandchildren. And I wish you many sunny successes.

Looking back in gratitude

Dr. Dieter Seifert began developing and disseminating the SK design in year 1984 and was enthusiastically accompanied by friends all over the world. He emphasizes that without the enthusiasm, support and competent advice from his wife Imma, the development of these powerful solar cookers with their diverse applicability would not have been possible.

Many individuals and organizations worldwide are already participating in the development and dissemination of the Open Source Appropriate Technology, inspired by the idea of contributing to better humane living conditions for everyone worldwide.

Photo E14: Solar cooker training program 2004 invited by Dr. Shirin and Deepak Gadhia in their Eco-Center ICNEER in Valsad / India, thanks to the Senior Experten Service (SES), Bonn / Germany

Appendix F About Production of Ben-Stoves
Appendix G About Production of Escolar School Solar Cookers
Appendix H Small PV-Systems with Tracking Device
Appendix I Proposal for a Cooking Kit for Emergency Situations