Fraunhofer

RESEARCH NEWS

12 | 2010

Fraunhofer Press
Phone: 089 1205-1302
presse@zv.fraunhofer.de
www.fraunhofer.de/presse

1 The taster in your water line

Although drinking water is monitored more strictly than almost anything, our water supply network is still not immune to accidents, wear and tear or targeted attacks. A one-minute warning system for toxins and other substances in water hazardous to health could set off alarms in future if there is a danger.

2 Tracking down particulates

Wood-burning stoves are enjoying a surge in popularity. But burning biomass releases fine dust particles that are hazardous to health. Consequently, new legal limits for particulate emissions from such stoves were introduced last March. Researchers have now developed a measuring device that determines precise levels of dust emissions.

3 Fast sepsis test can save lives

Blood poisoning can be fatal. If you suffer from sepsis, you used to have to wait as much as 48 hours for laboratory findings. A new diagnostic platform as big as a credit card will now supply the analysis after as little as an hour. This system is based on nanoparticles that are automatically guided by magnetic forces.

4 Hot embossing glass – to the nearest micrometer

The lens is what matters: if lens arrays could be made of glass, it would be possible to make more conveniently sized projectors. Fraunhofer researchers have now developed a process that allows this key component to be mass produced with extreme accuracy.

5 A robot with finger-tip sensitivity

Two arms, three cameras, finger-tip sensitivity and a variety of facial expressions – these are the distinguishing features of the pi4-workerbot. Similar in size to a human being, it can be employed at any modern workstation in an industrial manufacturing environment. Its purpose is to help keep European production competitive.

6 Less than they are worth

Supplying energy is in the process of metamorphosis because people want to know what is the most intelligent and efficient way to utilize all types of energy carriers. The researchers at Fraunhofer put the most common ideas for heating under the microscope and come up with major potential.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 59 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 17,000, who work with an annual research budget totaling 1.5 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

Editorial notes:
Research News l Frequency: monthly l ISSN 09 48 - 83 83
Published by Fraunhofer-Gesellschaft l Press Office l Hansastraße 27c l 80686 München, Germany l
Telefon +49 89 1205-1333 l presse@zv.fraunhofer.de
Editorial Staff: Franz Miller, Michaela Neuner, Brigitte Röthlein, Britta Widmann l Reprints free of charge.
We encourage you to favor the online version and newsletter via www.fraunhofer.de/fhg/EN/press
This bulletin is also available in German as “Mediendienst”.

Fraunhofer

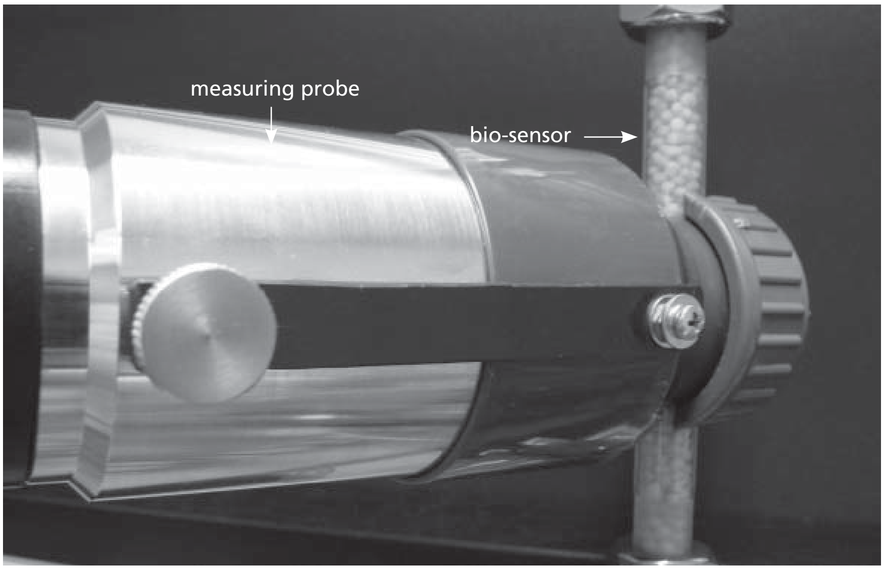
The taster in your water line

Research News
12-2010 I Topic 1

It is supposed to be cool, colorless, tasteless and odorless. It may not have any pathogens or impair your health. This is the reason why drinking water is put to a whole series of screenings at regular intervals. Now, the AquaBioTox project will be added to create a system for constant real-time drinking water monitoring. At present, the tests required by the German Drinking Water Ordinance are limited to random samples that often only provide findings after hours and are always attuned to specific substances. In contrast, the heart of the AquaBioTox system is a bio-sensor that reacts to a wide range of potentially hazardous substances after just a couple of minutes. It works on the taster principle. That is, some drinking water is diverted from the main line through the sensor in a branching descending line and it contains two different strains of bacteria and mammalian cells. On the one hand, these microscopically small bacteria have a large surface that guarantees quick material turnover and reacts to toxic substances within minutes. On the other hand, the mammalian cells clinch the results because of their close relationship to the human organism and they also extend the range of reactions. This is how Dr. Iris Trick from the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart, Germany sees it: "We tested various classes of substances that might occur in water – even though they shouldn't – and to date our sensor has reacted to each of these substances." She developed the bio-sensor in joint efforts with her colleague Dr. Anke Burger-Kentischer.

The micro-organisms in the sensor were modified so that they produce a protein that has a red fluorescence. The fluorescence changes if it comes into contact with toxic substances. A highly sensitive camera system that the Karlsruhe, Germany-based Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB came up with has an analysis unit that registers even the most minute changes in fluorescence and then analyzes them automatically. Dr. Thomas Bernard, the group manager at the IOSB, tells us why: "The monitoring unit has a machine-learning process for learning from historical data which fluctuations in the physical, chemical and biological parameters are normal. It sets off an alarm if an unusual pattern shows up in the signals." The bio-sensor reacts to the smallest quantities of hazardous substances and Dr. Trick provides the explanation: "Our sensor can document even very slight concentrations." Let's not forget that classical poisons such as cyanide or ricin as well as plant protectives or toxic metabolic products from bacteria can be fatal even in concentrations of nanograms per liter.

They have to guarantee optimum life conditions for the microorganisms to operate the bio-sensor on a permanent basis. This is the reason why the researchers at the IOSB have come up with a system that automatically monitors and regulates important parameters such as temperature and inflow of nutrients. Another component of the Aqua-BioTox system is a daphnia toximeter of their Kiel, Germany-based project partner bbe Moldaenke, who noticed that water fleas react particularly sensitively to nerve poisons. They are testing this monitoring system in a closed performance route on the grounds of Berlin's water company, that is incidentally another partner in this project. The idea behind it is making the system as small and cost-effective as possible so that a network of sensor units communicating with one another could be installed that is distributed over sensitive points in the drinking water network.



The red fluorescent bacteria in the glass tube change their color whenever the microorganisms in the bio-sensor come into contact with toxic substances. The measuring probe shows the intensity of fluorescence. (© Fraunhofer IGB)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB | www.igb.fraunhofer.de | **Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB** | www.iosb.fraunhofer.de | **Contact:** Dr. Iris Trick | Phone +49 711 970-4217 | iris.trick@igb.fraunhofer.de | Dr. Thomas Bernard | Phone +49 721 6091-360 | thomas.bernard@iosb.fraunhofer.de
Press: Claudia Vorbeck | Phone +49 711 970-4031 | claudia.vorbeck@igb.fraunhofer.de
Sibylle Wirth | +49 721 6091-300 | sibylle.wirth@iosb.fraunhofer.de

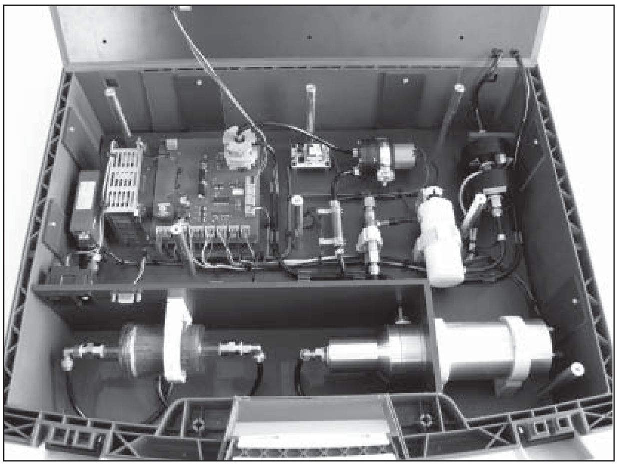
Tracking down particulates

For some years now, consumers have been making increasing use of wood as a fuel – and not only on account of the rising cost of heating oil and natural gas. "Comfort fireplaces" have become all the rage because open fires, tiled and wood-burning stoves give a room a snug and cozy feel. But using wood for heating has one distinct disadvantage. When pellets, logs or briquettes are burnt, fine dust particles that are hazardous to health are released into the atmosphere. These particles are known to cause coughs, place stress on the cardiovascular system, and are thought to be carcinogenic. Indeed, studies by the World Health Organization have found that fine dust particles reduce average life expectancy in Germany by approximately ten months.

According to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, there are now 14 million small, single-room combustion plants installed all over Germany – and that figure is on the rise. Wood use by private individuals has gone up by 60 to 80 per cent since the year 2000. In 2004, emissions from domestic heating systems exceeded road traffic emissions for the first time ever. Earlier this year, in an attempt to deal with this increase in pollution, the federal government passed an amendment to the First Ordinance on the Implementation of the Federal Immission Control Act, and new pollution limits for small combustion plants – which include both wood-burning stoves and wood-fired boilers – came into effect at the end of March. One significant change is that these limits now apply to heating systems with a rated heat output of 4 kilowatts or more, whereas previously only systems with a rated heat output of 15 kilowatts or more were affected. As a result, the number of stoves that will have to be inspected for dust emissions will rise dramatically.

Working together with the firm Vereta, researchers at the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM in Hannover and the Institute for Mechanical Process Engineering at Clausthal University of Technology have now developed a measuring device that determines levels of fine dust emissions at source. The project was funded by the German Federation of Industrial Research Associations (AiF), and Professor Wolfgang Koch, head of department at the ITEM, explains their achievement: "To date there is no validated method for measuring the dust content in flue gases. The Bosch smoke count method used with oil-fired heating systems is not appropriate, as it looks primarily at soot particles, and soot is not the principal component of emissions from wood-fired combustion. Our device makes it possible to measure particulate concentrations instead. To do this, we simply place a sampling probe developed by us in the stove flue." The probe draws off some of the flue gases, which are diluted with pre-treated air at the tip of the probe and then cooled in a conditioning unit. The conditioned flue gases are subsequently fed through two optoelectronic sensors which use different measuring techniques: the aerosol light-scattering photometry method devised by ITEM, and the aerosol photoemission method developed by Clausthal University of Technology. An algorithm combines the electrical signals from both these sensors to produce a definitive reading.

Professor Alfred Weber of Clausthal University of Technology is proud to report: "We have successfully tested a prototype of the new measuring device. We conducted numerous tests on wood-burning stoves that were being run on a variety of fuels, and were able to prove a linear relationship between the calculated signal received from the device and the mass concentration that was simultaneously measured using a filtering process. This innovative technology provides heating engineers with a cost-effective tool for determining the precise concentration of particulate matter." The researchers have applied for a patent for their new measuring method, and Vereta, supplier of the electronic control technology that supports the sensor, has submitted the device for evaluation by the German Technical Inspection Association (TÜV).



Chimney sweeps and heating engineers can use the portable measuring equipment to determine particulate concentration in a stove. (© Fraunhofer ITEM)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Toxicology and Experimental Medicine ITEM
Nikolai-Fuchs-Straße 1 | 30625 Hannover, Germany | www.item.fraunhofer.de
Contact: Prof. Dr. Wolfgang Koch | Phone +49 511 5350-117 | wolfgang.koch@item.fraunhofer.de
Press: Karola Neubert | Phone +49 511 5350-225 | karola.neubert@item.fraunhofer.de

Fraunhofer

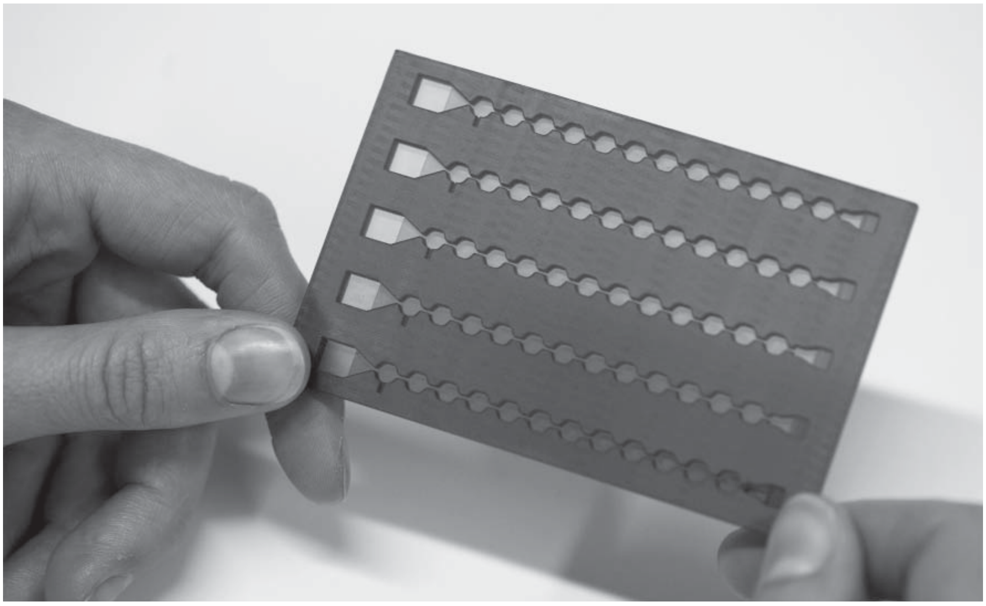
Fast sepsis test can save lives

Although it is the third most frequent cause of death in Germany, blood poisoning is frequently underestimated. In this country, 60,000 persons die every year from some form of sepsis, almost as many as from heart attacks. The Sepsis Nexus of Expertise states that patients arriving at the intensive care ward with blood poisoning only have a 50% chance of surviving. One of the reasons for the high mortality rate is the fact that patients are not correctly treated due to late diagnosis. The doctor and the patient used to have to wait as much as 48 hours for the laboratory analysis.

In future, a new mobile diagnostics platform will be guaranteeing fast and low-cost infection diagnostics even while the patient is being transported to the hospital. It's called MinoLab and it consists of a plastic card the size of a credit card that is inserted in an analysis unit that is smaller than a notebook. This system provides findings in less than one hour to enable the doctor to prescribe the life-saving therapy. This is based on magnetic particles that dock onto the cells to be studied in a blood sample and run through the system fully automatically with magnetic force. At the end of the process, the diagnosis is made with magnetic sensors. MinoLab is presently being developed in a project of the German Federal Ministry of Education and Research by the Fraunhofer Institute for Cell Therapy and Immunology (IZI) in Leipzig, Germany in collaboration with Magna Diagnostics, a company hived off from the Fraunhofer Society. Other project partners are the Fraunhofer Institute for Reliability and Micro-integration (IZM) in Berlin as well as the companies Siemens, Dice, microfluidic Chip Shop and the Austrian Institute of Technology.

Dr. Dirk Kuhlmeier, a scientist at the Fraunhofer Institute for Cell Therapy and Immunology, explains how all that works: "After taking a sample of blood, magnetic nanoparticles bind themselves to the target cells in the blood sample through specific catcher molecules. We then use a simple magnet to transfer the particles onto the plastic card along with the pathogens and move them through various miniaturized reaction chambers which is where the polymerase chain reaction takes place. This is a method for copying even the smallest DNA sequences of pathogens millions of times. After it is copied, the nanoparticles transport the pathogen DNA into the detection chamber where a new type of magnetoresistive biochip can identify pathogens and antibiotics resistances." Our researcher goes on: "All reactions starting from sample preparation through isolating the target molecules right down to documentation are carried out without any contact and fully automatically." This means that routine operation is made much simpler for the laboratory technician and it reduces the risk of contamination from bacteria introduced from the environment that set off false alarms. But there is another benefit, as Dr. Kuhlmeier explains: "We not only save time with the combination of magnetic nanoparticles in a new type of micro-fluid. Miniaturization means we also save expensive apparatuses."

The experts have already been successful at using magnetic nanoparticles to isolate and document the sepsis pathogens, although Kuhlmeier says, "it will be another two years or so until we are able to produce a prototype of the diagnostic platform." Platform technology is not only suited for sepsis tests. It will be able to back up doctors in hospitals and private practices answering a wide range of molecular biological issues ranging from genetic predisposition right down to cancer diagnostics.



The magnetic nanoparticles transport the pathogen DNA into the detection chambers (on the right) on this plastic card. This is a prototype of the card for the fast sepsis test. (© Fraunhofer IZI)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Cell Therapy and Immunology IZI
Perlickstraße 1 | 04103 Leipzig, Germany | www.izi.fraunhofer.de
Contact: Dr. Dirk Kuhlmeier | Phone +49 341 35536-9312 | dirk.kuhlmeier@izi.fraunhofer.de
Press: Dr. Wilhelm Gerdes | Phone +49 341 35536-9305 | wilhelm.gerdes@izi.fraunhofer.de

Fraunhofer

Hot embossing glass – to the nearest micrometer

Research News
12-2010 I Topic 4

Projectors are getting smaller and smaller. Now that pictures are available in digital format almost everywhere, we need projectors to beam giant photos and films onto walls. Projectors contain lenses that spread the light from the pixelated source in such a way as to illuminate the image area evenly. Until now, this was done using complicated arrays of lenses placed one behind the other. Recently, the same effect has been achieved using flat lens arrays made up of thousands of identical microlenses. This kind of array takes up much less space and does not need to be painstakingly assembled and aligned. To date it has only been possible to manufacture these lens arrays from plastic, but the light source in conventional projectors is hot enough to melt them. To get around this problem, Jan Edelmann and his team at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz have developed a process for manufacturing lens arrays from glass, whereby the surface structure of the array is hot embossed into viscous glass at temperatures of between 600 and 900 degrees Celsius. "The main challenge is to keep the material exactly at the temperature where it is malleable but not yet molten," explains the project manager. "That is the only way to guarantee that components made from it will be within the prescribed tolerances to within a few micrometers."

The first step is to produce the forming die equipment, using tungsten carbide which is machined with ultra-precise grinders. "Of course, we have to take into account right from the beginning that the high temperatures will cause both the glass and the equipment to expand, but at different rates", says Edelmann. "So the die has to be a slightly different shape from the workpiece that we are looking to produce." Considering that 1700 absolutely identical square microlenses must fit into an area of just five square centimeters, it is not hard to imagine the level of precision that is required, and it is no surprise that it takes hours to produce the die. Once it is finished, the die is given a wear-resistant coating of precious metal.

During hot embossing, which takes place in a vacuum chamber, it is important for the glass and the equipment to be kept at a constant temperature until the workpiece has been ejected from the mold. The reason for this is that, during the cooling process, the glass shrinks more than the equipment. Tensions would otherwise arise and the lenses, only millimeters thick, might shatter. For ease of handling, the IWU researchers have given the workpiece an edge. Here, too, precision is of the utmost importance. Both stamping dies must be aligned exactly with one another, and there must be no slippage or distortion when they are pressed together.

The team from IWU has overcome all these problems and succeeded in producing arrays from high refraction glass that have extremely smooth surfaces and where alignment faults across all 1700 microlenses are smaller than 20 micrometers. "This is a world's first," says Edelmann happily. The process is suitable for use in mass production, and could bring the price of such components down to a tenth of what current lenses cost. Furthermore, arrays of this kind are not only important for projectors. They could also be used to broaden and homogenize laser beams, for example in industrial welding machines.

The finished lens array is at a slant behind the lower die set of the hot embossing equipment. (© Fraunhofer IWU)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Machine Tools and Forming Technology IWU
Reichenhainer Straße 88 | 09126 Chemnitz, Germany | www.iwu.fraunhofer.de
Contact: Jan Edelmann | Phone +49 371 5397 1931 | jan.edelmann@iwu.fraunhofer.de
Press: Kathrin Reichold | Phone +49 371 5397 1454 | kathrin.reichold@iwu.fraunhofer.de

A robot with finger-tip sensitivity

Picture the following: With great care, a robot picks up a gear wheel in one hand, a housing in the other, and places the two together. When they don't immediately engage, it breaks off its movement. Slowly, it twists the gear wheel round a little and tries again. This time the wheel slots easily into its mounting. The robot smiles, and places the correctly assembled part on the conveyor belt. The pi4-workerbot is capable of making many more movements than a normal robot and is the jewel in the crown of the EU-funded PISA research project, which aims to introduce greater flexibility into industrial mass production by using robots in assembly processes. All manufacturers operating in Germany need technology that can be adapted for and cope with a variety of product versions and fluctuating volumes. And because workforce requirements also change in line with orders on company books, the idea is that manufacturers should even be able to lease these robots as and when necessary. Dr.-Ing. Dragoljub Surdilovic, head of the working group at the Fraunhofer Institute for Production Systems and Design Technology IPK in Berlin, says: "We developed the workerbot to be roughly the same size as a human being." Which means it can be employed at any modern standing or sitting workstation in an industrial manufacturing environment.

The robot is equipped with three cameras. A state-of-the-art 3D camera in its forehead captures its general surroundings, while the two others are used for inspection purposes. The workerbot can perform a wide range of tasks. Matthias Krinke, Managing Director of pi4-Robotics, the company that is bringing the workerbot onto the market, explains: "It can measure objects or inspect a variety of surfaces." To give an example, the robot can identify whether or not the chromium coating on a workpiece has been perfectly applied by studying how light reflects off the material. Krinke adds: "If you use two different cameras, it can inspect one aspect with its left eye, and another with its right." Moreover, the workerbot is also capable of inspecting components over a continuous 24-hour period – an important advantage when precision is of the utmost importance, such as in the field of medical technology, where a defective part can, in the worst case scenario, endanger human life.

Another distinctive feature of the pi4-workerbot is that it has two arms. "This allows it to carry out new kinds of operations," says Surdilovic. "These robots can transfer a workpiece from one hand to the other." Useful, for instance, for observing complex components from all angles. The Fraunhofer researcher continues: "Conventional robotic arms generally only have one swivel joint at the shoulder; all their other joints are articulated. In other words, they have six degrees of freedom, not seven like a human arm." However, as well as the swivel joint at its shoulder, the workerbot has an additional rotation facility which corresponds to the wrist on a human body. Surdilovic's working group developed the control system for the workerbot. He recalls: "Programming the two arms to work together – for example, to inspect a workpiece or assemble two components – was a real challenge. It requires additional sensor systems."

The researchers also endowed the robot with finger-tip sensitivity. "If you set the strength of the grip correctly, it will take hold of an egg without cracking it," says Surdilovic. And it even has a variety of facial expressions. If its work is going smoothly, it will smile happily. If it looks bored, it's waiting for work, and the production manager knows the production process can be speeded up.

The workerbot is roughly the same size as a human being. (© pi4_workerbot)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Production Systems and Design Technology IPK
Pascalstraße 8 - 9 l 10587 Berlin, Germany l www.ipk.fraunhofer.de
Contact: Dr.-Ing. Dragoljub Surdilovic l Phone +49 30 39006-172 l dragoljub.surdilovic@ipk.fraunhofer.de
Press: Steffen Pospischil l Phone +49 30 39006-140 l steffen.pospischil@ipk.fraunhofer.de

Less than they are worth

Carsten Beier from the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen, Germany does not believe that "anyone would burn a 50-dollar bill just to keep warm. It's obvious that it simply is too valuable for that." But, in contrast to dollar bills, most energy carriers are all too frequently burned for less than they are worth. Take wood, for example. Beier and his colleagues have analyzed the efficiency of heat supply systems and he explains that "wood is a high-quality fuel that can be compared to natural gas. With adequate technologies we could utilize it for power generation. As a fuel, there's a lot more in wood that we are taking advantage of at the moment."

Beyond this, the researchers at the Fraunhofer Institute for Environmental, Safety and Energy Technology have come up with a model for comparing various systems and technologies in heat supply ranging from heating boilers for single-family dwellings right down to district heating networks for whole cities. They apply exergy as a criterion of analysis which is a thermodynamic parameter defined by the quantity and quality of an energy. In contrast to the CO_2 balance sheet and primary energy consumption, the exergy analysis indicates whether we are sufficiently taking advantage of the potential lying dormant in the energies we use. Carsten Beier has come to the conclusion that "if we used fuels such as natural gas or wood for power generation and only use the waste heat for heating, we would be able to save large quantities of primary energy and avoid generating CO_2 emissions."

Cogeneration plants are taking advantage of these potentials. While large-scale power plants lose an average of 60 percent of the energy as waste heat through the cooling tower, cogeneration plants use this flow of heat for heating purposes, which means that they achieve overall efficiency of more than 80 percent. The researchers distinguished four categories of heat generation in their analyses: burning, cogeneration and using heat pumps or waste heat from industrial processes. Comparing these categories, using waste heat was particularly good in connection with heat networks. That said, it also became apparent that the way drinking water was heated was a key factor in exergy efficiency. Beier reveals that "even heating a room with waste heat has a poor overall exergy balance sheet if the service water for the household is electrically heated."

Researchers derived one basic recommendation from their comparison of systems and technologies. Beier demands "we should take advantage of all sources of heat whose temperature level corresponds to our heating requirements.” And we could take advantage of the fact that there are a whole series of applications where heat is needed at different temperature levels. Beier explains how. ”Any type of cascade is very efficient. For instance, if you use fuel for power generation first, then the waste heat for water heating and finally the remaining heat for space heating.” He confesses that there might be discussions on the economic efficiency of these scenarios, especially because the initial investments are rather high. “But, on the other hand, it is essential to restructure our energy system quickly and an exergy analysis is an excellent tool for identifying how power supply should be designed in future.”

60 percent of the energy used in large-scale power plants is lost as waste heat through the cooling tower. (© Fraunhofer UMSICHT)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
Osterfelder Straße 3 I 46047 Oberhausen, Germany I www.umsicht.fraunhofer.de
Contact: Dipl.-Ing. Carsten Beier I Phone +49 208 8598-1416 I carsten.beier@umsicht.fraunhofer.de
Press: Dipl.-Chem. Iris Kumpmann I Phone +49 208 8598-1200 I iris.kumpmann@umsicht.fraunhofer.de