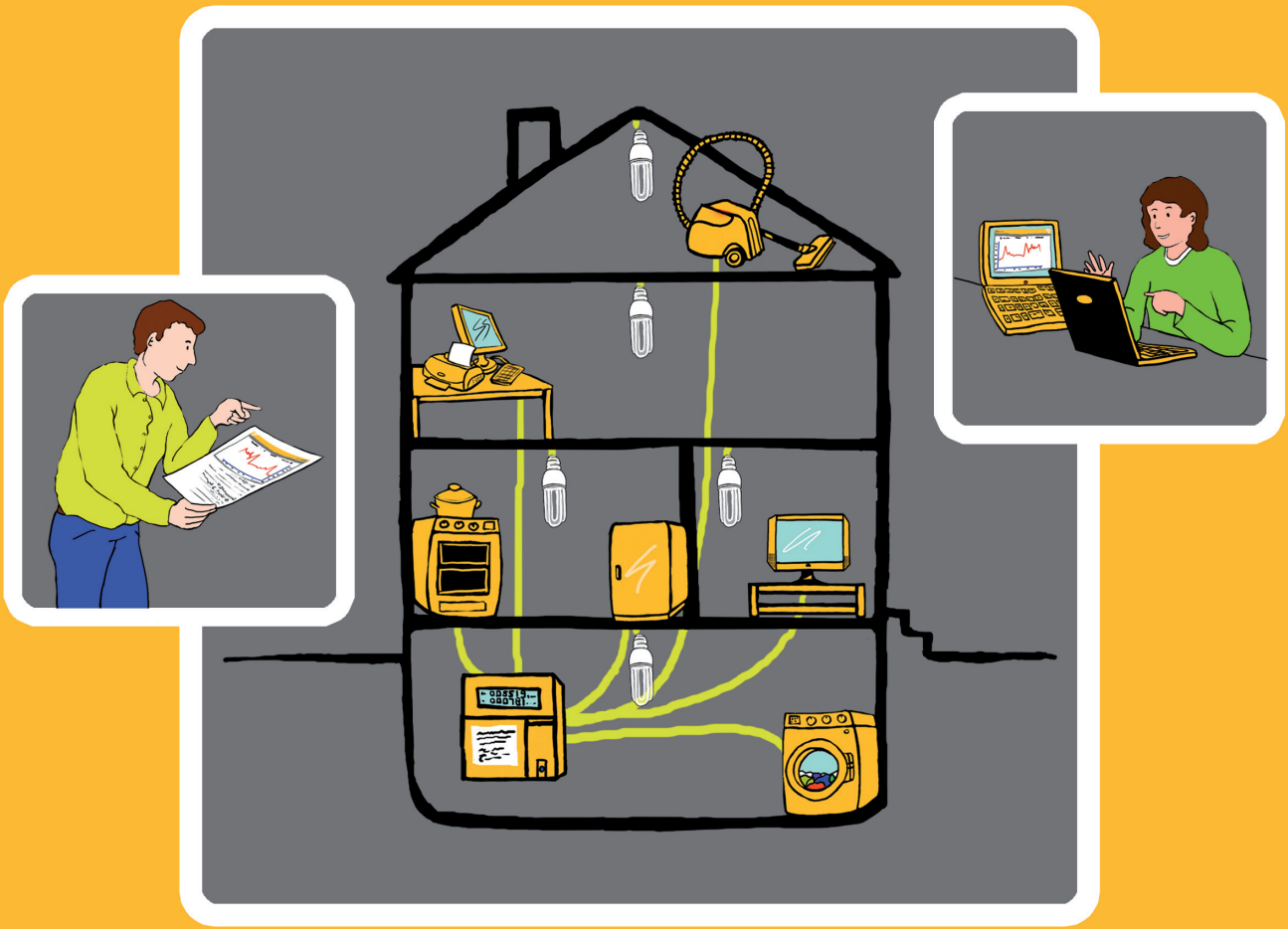
Intelliekon

Achieving Sustainable Energy Consumption with Smart Metering, Communication and Tariff Systems



Results – November 2011

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FONA Social-Ecological Research BMBF

Imprint

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Intelliekon was funded by the Federal Ministry for Education and Research (BMBF) Grant number: 01UV0804A

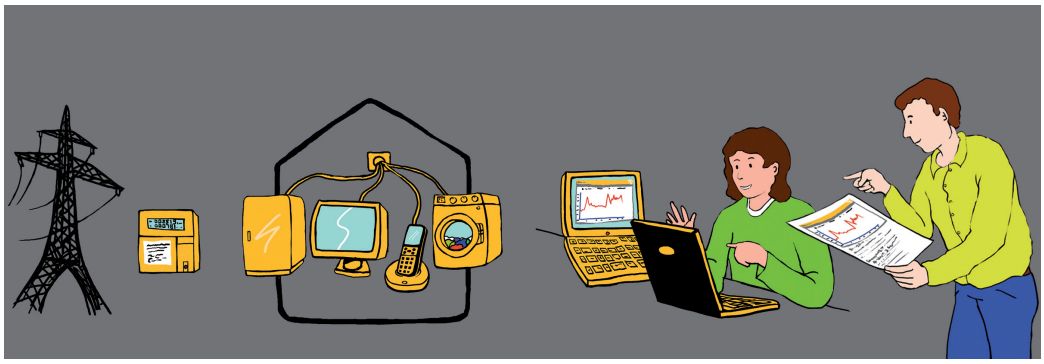
Design and Illustration: blatteins, Freiburg

The team of the project Intellikeon

The Intelliekon project

Intelliekon investigated energy saving in 2000 households

”Are you trying to save energy at home?” – Almost everybody can answer this question with ”yes”. Although the intention to do so is not enough to save energy: the energy squanderers in a household need to be identified first, just as every person in the household needs to know which habits are unnecessarily energy-wasting and therefore cost-intensive, and how they can be improved. A while ago, a new technical possibility was developed to help people to save energy: Smart Meters that record when energy was used to the split second. After automatic meter reading, the data can be forwarded to the household occupants very soon after use – via internet, SMS, a message to a smart phone or by traditional postage. In the Intelliekon project – an abbreviation for ”sustainable energy consumption with smart metering, communication and tariff systems“ – scientists wanted to determine whether energy can be saved by this type of feedback on electricity consumption. In a scientific project, researchers and energy utilities developed possibilities to communicate information on energy consumption back to the user, so-called feedback instruments, and examined the influence of the feedback on energy-related behavior of the participating households. With funding from the German Federal Ministry for Education and Research (BMBF), a large field trial was conducted with over 2000 households to examine their behavior when feedback instruments were used and to gather valuable data on energy saving due to feedback and smart meters.



Questions

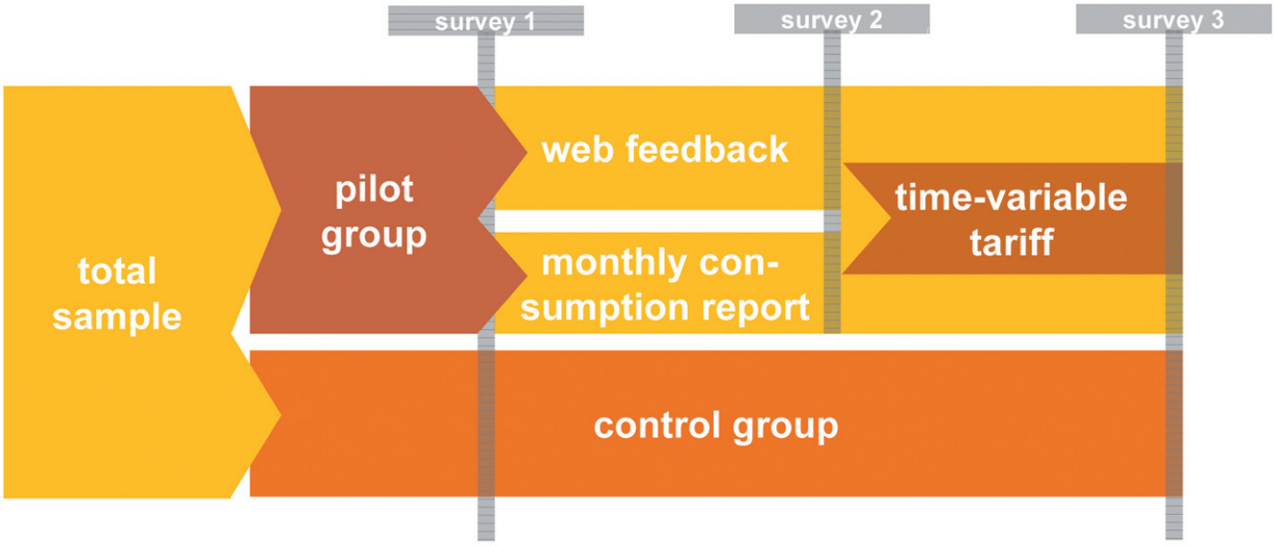
- Which attitudes towards feedback and energy saving do people have?
- How do participants use the offered web portal? (How often? How long? Which content do they favor?)
- Is a time-dependent tariff an adequate incentive to shift the time of energy consumption?
- What about the willingness to pay for feedback instruments?
- Can energy savings be attained by feedback? (If yes: to which amount?)
- What is the ecological effect that can be achieved by these energy savings (CO_2 emissions)? What are the implications when these results are extrapolated to the federal German energy system?

The Intelliekon field trial

Participants were able to log on to a web portal to see their own electricity consumption

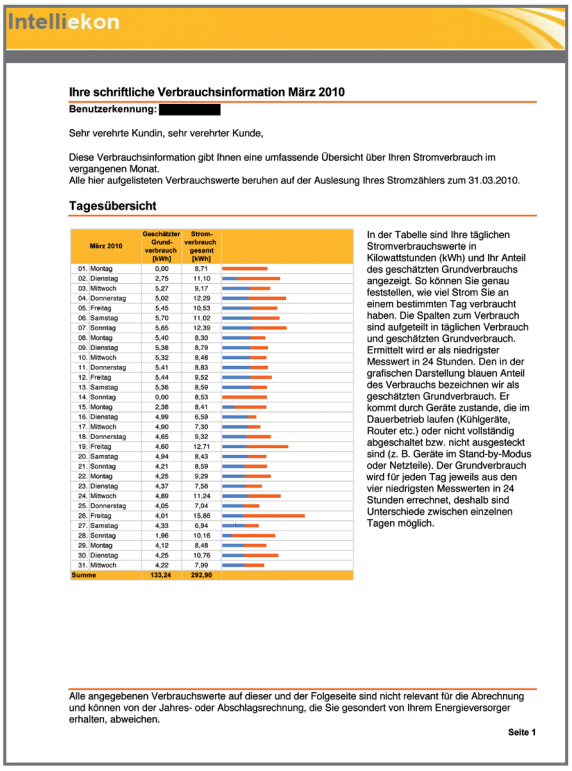
Nine German utilities and one Austrian utility were involved in the field trial. They wrote to their customers who already had a smart meter installed or were due to get one with the support of EVB energy solutions, and offered them the opportunity to take part in the field trial. In this way, more than 2000 households were motivated to take part. The sample contained people of different ages, genders, household sizes and living conditions. More than half of the sample received feedback on their energy consumption for more than a year. They could choose between a web portal or written feedback. With the web portal, they could log on whenever they wanted to determine their energy consumption. Those who did not want to or could not use the Internet received written information by post once a month. People with one of these feedback options were surveyed three times during the field trial. They were asked about their attitudes and motives towards feedback and energy saving as well as their evaluation of the feedback. The energy consumption of the participating households was recorded on an hourly basis. The other households also received a smart meter, but they did not get any feedback on their consumption. They were surveyed twice – at the beginning and at the end of the field trial – and their electricity consumption was also recorded. A control group like this is important to be able to compare households with and without energy feedback. Moreover, some of the people receiving feedback could choose a tariff with two price levels which varied depending on the time of the day.

Intelliekon flow diagram showing the different test conditions.



Feedback systems

The information provided via a web portal or written information was intended to provide a basis for consumers to analyze their own energy consumption themselves.



Intelliekon

Ihre schriftliche Verbrauchsinformation März 2010

Benutzerkennung: [redacted]

Sehr verehrte Kundin, sehr verehrter Kunde,

Diese Verbrauchsinformation gibt Ihnen eine umfassende Übersicht über Ihren Stromverbrauch im vergangenen Monat.
Alle hier aufgelisteten Verbrauchswerte beruhen auf der Auslesung Ihres Stromzählers zum 31.03.2010.

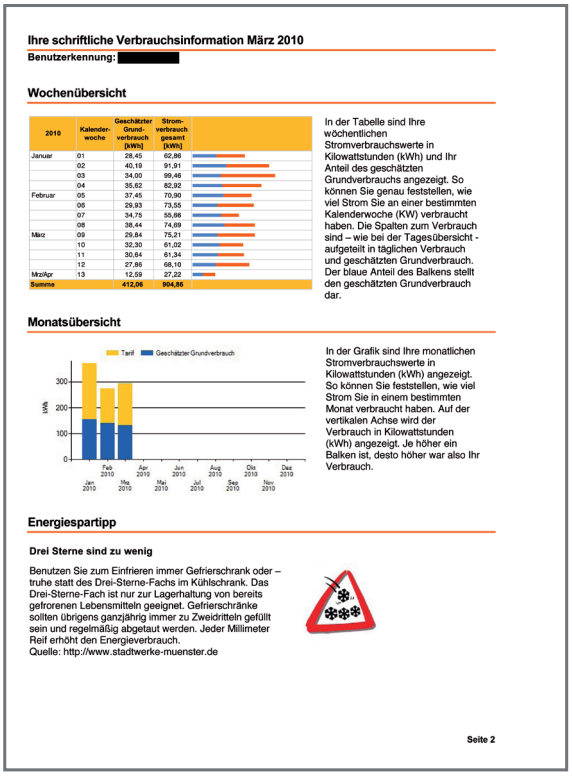
Tagesübersicht

März 2010	Geschätzter Grund-verbrauch [kWh]	Strom-verbrauch gesamt [kWh]
01. Montag	0,00	8,71
02. Dienstag	2,75	11,10
03. Mittwoch	5,27	9,17
04. Donnerstag	5,02	12,29
05. Freitag	5,45	10,53
06. Samstag	5,70	11,02
07. Sonntag	5,65	12,39
08. Montag	5,40	8,30
09. Dienstag	5,38	8,79
10. Mittwoch	5,32	8,48
11. Donnerstag	5,41	8,83
12. Freitag	5,44	9,52
13. Samstag	5,36	8,59
14. Sonntag	0,00	8,53
15. Montag	2,98	8,41
16. Dienstag	4,99	6,59
17. Mittwoch	4,90	7,30
18. Donnerstag	4,65	9,32
19. Freitag	4,60	12,71
20. Samstag	4,94	8,43
21. Sonntag	4,21	8,59
22. Montag	4,25	9,29
23. Dienstag	4,37	7,58
24. Mittwoch	4,89	11,24
25. Donnerstag	4,05	7,04
26. Freitag	4,01	15,86
27. Samstag	4,33	6,94
28. Sonntag	1,96	10,16
29. Montag	4,12	8,48
30. Dienstag	4,25	10,76
31. Mittwoch	4,22	7,99
Summe	**133,24**	**292,90**

In der Tabelle sind Ihre täglichen Stromverbrauchswerte in Kilowattstunden (kWh) und Ihr Anteil des geschätzten Grundverbrauchs angezeigt. So können Sie genau feststellen, wie viel Strom Sie an einem bestimmten Tag verbraucht haben. Die Spalten zum Verbrauch sind aufgeteilt in täglichen Verbrauch und geschätzten Grundverbrauch. Ermittelt wird er als niedrigster Messwert in 24 Stunden. Den in der grafischen Darstellung blauen Anteil des Verbrauchs bezeichnen wir als geschätzten Grundverbrauch. Er kommt durch Geräte zustande, die im Dauerbetrieb laufen (Kühlgeräte, Router etc.) oder nicht vollständig abgeschaltet bzw. nicht ausgesteckt sind (z. B. Geräte im Stand-by-Modus oder Netzteile). Der Grundverbrauch wird für jeden Tag jeweils aus den vier niedrigsten Messwerten in 24 Stunden errechnet, deshalb sind Unterschiede zwischen einzelnen Tagen möglich.

Alle angegebenen Verbrauchswerte auf dieser und der Folgeseite sind nicht relevant für die Abrechnung und können von der Jahres- oder Abschlagsrechnung, die Sie gesondert von Ihrem Energieversorger erhalten, abweichen.

Seite 1



Ihre schriftliche Verbrauchsinformation März 2010

Benutzerkennung: [redacted]

Wochenübersicht

2010	Kalender-woche	Geschätzter Grund-verbrauch [kWh]	Strom-verbrauch gesamt [kWh]
Januar	01	28,45	62,86
	02	40,19	91,91
	03	34,00	99,46
	04	35,62	82,92
Februar	05	37,45	70,90
	06	29,93	73,55
	07	34,75	55,66
	08	38,44	74,69
März	09	29,84	75,21
	10	32,30	61,02
	11	30,64	61,34
	12	27,86	68,10
Mrz/Apr	13	12,59	27,22
Summe		**412,06**	**904,86**

In der Tabelle sind Ihre wöchentlichen Stromverbrauchswerte in Kilowattstunden (kWh) und Ihr Anteil des geschätzten Grundverbrauchs angezeigt. So können Sie genau feststellen, wie viel Strom Sie an einer bestimmten Kalenderwoche (KW) verbraucht haben. Die Spalten zum Verbrauch sind – wie bei der Tagesübersicht - aufgeteilt in täglichen Verbrauch und geschätzten Grundverbrauch. Der blaue Anteil des Balkens stellt den geschätzten Grundverbrauch dar.

Monatsübersicht

In der Grafik sind Ihre monatlichen Stromverbrauchswerte in Kilowattstunden (kWh) angezeigt. So können Sie feststellen, wie viel Strom Sie in einem bestimmten Monat verbraucht haben. Auf der vertikalen Achse wird der Verbrauch in Kilowattstunden (kWh) angezeigt. Je höher ein Balken ist, desto höher war also Ihr Verbrauch.

Energiespartipp

Drei Sterne sind zu wenig

Benutzen Sie zum Einfrieren immer Gefrierschrank oder –truhe statt des Drei-Sterne-Fachs im Kühlschrank. Das Drei-Sterne-Fach ist nur zur Lagerhaltung von bereits gefrorenen Lebensmitteln geeignet. Gefrierschränke sollten übrigens ganzjährig immer zu Zweidritteln gefüllt sein und regelmäßig abgetaut werden. Jeder Millimeter Reif erhöht den Energieverbrauch.
Quelle: http://www.stadtwerke-muenster.de

Seite 2

All participants were offered access to an "Intelliekon" web portal, that had been developed by EVB Energy Solutions and Fraunhofer ISE. After log-in, this web portal presented an overview of the energy they had been using. The users had the possibility to have their own energy consumption displayed for each hour, day, week or month. Automatic data analysis split the consumption into base load, i.e. standby electricity consumption, electricity consumption caused by cooling appliances (blue), and other electricity consumption (yellow). Apart from these graphs, the web portal presented practical advice on energy saving. Participants had the possibility to download their consumption data easily and to save it. In this way, they could analyze their consumption behavior exactly. The written information was mainly sent to people who did not have any access to the Internet. However, it was also addressed to those who simply preferred the written form. This information was posted once a month and it showed the energy consumption of the previous months, weeks and days. As in the web portal, a base load share of energy consumption was estimated and the information contained advice on energy saving.

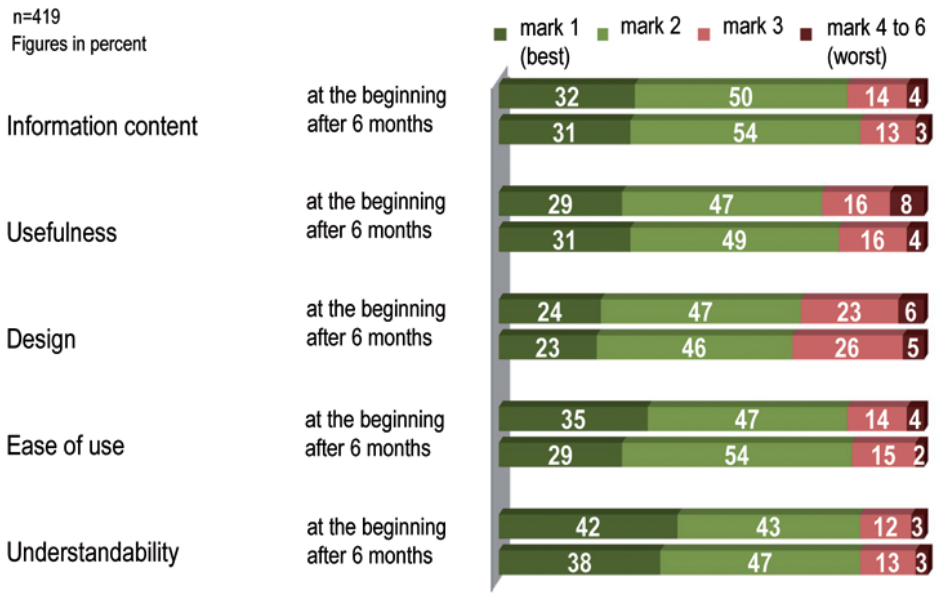
The consumption report showed the energy consumption of the previous months. Such a report was posted to the households which had selected this option once a month.

Acceptance and desirability of the feedback

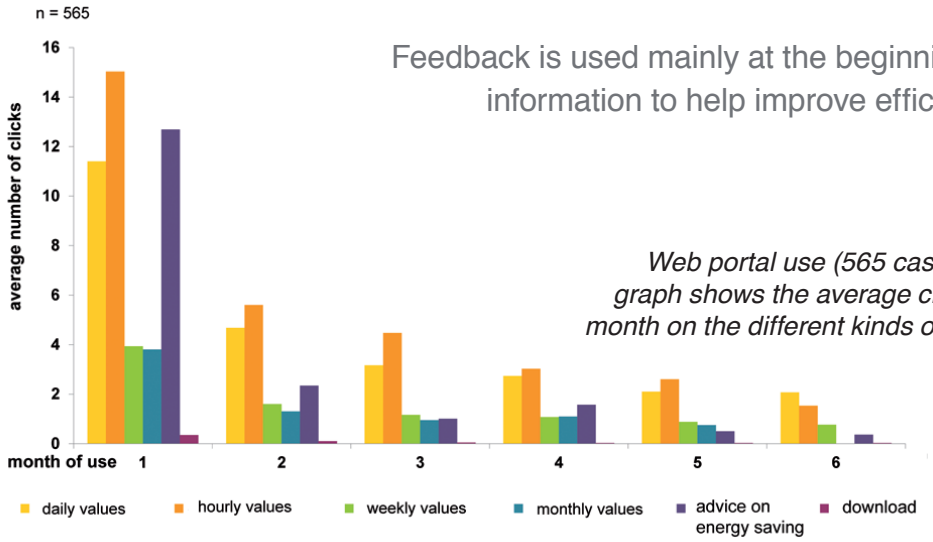
The feedback system in Intellikeon was perceived positively by those taking part in the field trial.

The Institute for Socio-Ecological Research (ISOE), Frankfurt, interviewed the people participating in the field trial about their acceptance and the desirability of the feedback information. The outcome was certainly positive: Users perceived the feedback predominantly as informative, helpful, well-designed, easy to use and understandable. Only a minority was concerned about data security. A still smaller minority stated that being involved consciously in energy-consumption matters was inconvenient and time-killing. Most people surveyed showed a clear willingness to save energy. The feedback instrument was suitable for supporting them. “However, well-displayed and promptly presented information does not lead automatically to a reduction in electricity consumption”, stresses ISOE project leader, Dr. Konrad Götz. Comparing the two feedback instruments used in the project shows that the written information was judged almost as positively as the web portal. Suggestions for improving the feedback, suggested by users, included: A display of the energy consumption in real time and a breakdown of the electricity consumption for each appliance in the web portal. After having access to the feedback instruments for half a year, people evaluated them nearly as positively as at the beginning. The rating regarding usability even improved a little. A feedback system can be designed in many ways. The feedback instruments in Intelliekon showed that they are highly accepted by users. The offer of monthly written information is also valuable for a certain target group.

Assessments of the web portal at the beginning of the experiment and after 6 months. Results as percentage values; 419 surveys analyzed.



Web portal use



Feedback is used mainly at the beginning as information to help improve efficiency.

Web portal use (565 cases). The graph shows the average clicks per month on the different kinds of pages.

With consent from the participants, the scientists from Fraunhofer ISE traced web portal use by recording the clicks on each web page. When analyzing the data, scientists found that feedback information was demanded by most users only during the first two months of the field trial. Roughly one third of the sample accessed the web portal only once. All the others were much more active in interacting with the web portal, although only 5 % used the web portal frequently. Suggestions for practical action seem to be particularly important, as one quarter of web portal users was interested especially in the suggestions offered for energy saving. Although it was used in very different ways, the whole range of information offered by the feedback system in Intelliekon seems to be important. To use the web portal, users had to log in repeatedly. Thus, it is possible that some of them stopped using the web portal because they lost their password or just forgot about the web portal. Moreover the survey revealed that households were using the web portal for different purposes: Those who wanted to use it to learn how to save more energy collected the information for several months. Those who wanted to make sure that they would not have to readjust their payments when they received the next bill only used it for a few months. Evidently, the feedback offered information which was interesting for different purposes. Indeed, it seems to be interesting mainly at the beginning as information to help improve efficiency, but not continuously as the scientists had been expecting.

Effects on consumption

In the field trial, a reduction of consumption of 3.7 % was identified.

To answer the important question of whether any energy is actually saved due to the feedback, the scientists from Fraunhofer ISI had to do elaborate calculations. Only once they knew the influence of different equipment and appliances in households could a statement about the saving effects of feedback be made. As a matter of fact, the group with feedback had an energy consumption which was 3.7 % lower than the reference group. This amounts to an average of 125 kWh per year. The difference between the groups with and without feedback is a little smaller than expected – older studies from other countries found savings of 7 %, although the circumstances were very different there. In Linz, the effect stayed at the same level during the whole field trial, whereas in Germany no reliable statement about the stability of the effects can be made as the data basis was too small there. ”Smart Metering is a vital topic in the current energy debate, because an improvement in household energy efficiency is expected from this technology. For the first time now we could show what potential there really is in a large and well-planned social-scientific investigation,“ said Sebastian Gölz, psychologist and overall project leader at Fraunhofer ISE.

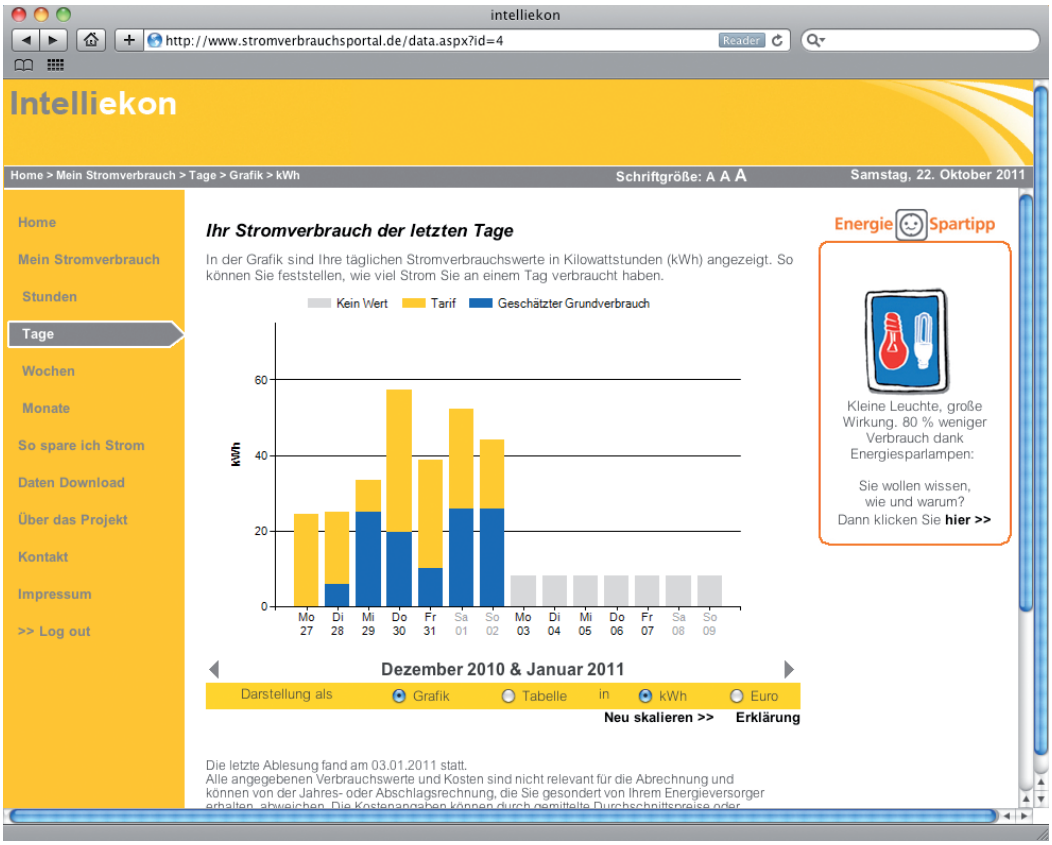
Effects on consumption

Energy savings do not only depend on web portal use.

When converted to the total German energy consumption, 3.7 % is equivalent to a reduction of 5 TWh per year and avoided energy costs of1 billion euros in households. The field trial had a longer-term effect as well: "In our analyses, we have shown that energy-saving effects are still traceable even several months after the start of the field trial", says subproject leader, Dr. Marian Klobasa from Fraunhofer ISI.

Furthermore, the scientists from Fraunhofer ISE and Fraunhofer ISI wanted to know whether savings had any correlation with the frequency and type of feedback use, so they analyzed data on feedback use and energy consumption. In doing so, they found that savings do not depend only on feedback use. Within the group of "minimal users" – i.e. those who dealt only once very briefly with the feedback – they could find a saving rate of 9 %. However, also those who considered their hourly values and their load profile in detail saved markedly more than the average. It was also shown that every click on a new piece of information led to an average of 0.7 % energy saved, but this effect was not permanent over time, as the web portal was not used for longer than two to three months. The usage (i.e. the selection of pages with energy-saving advice) led to an average of 10 kWh energy saved.

Screen shot of the web portal.

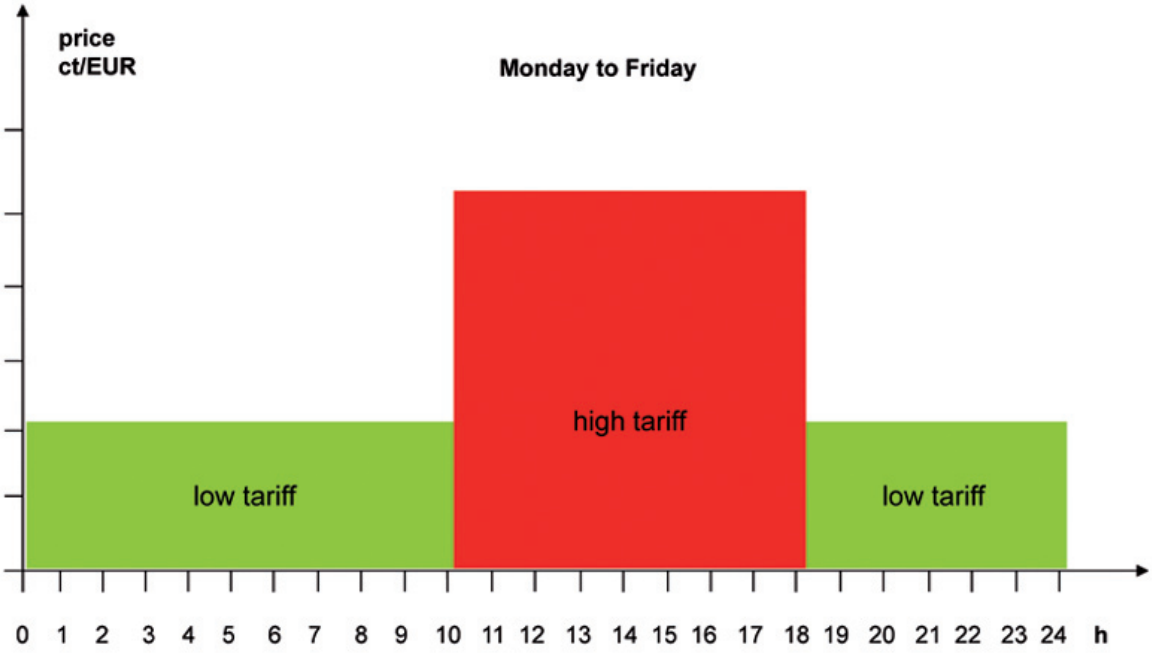


Time-variable tariff

Households with a time-variable tariff attained an extra energy saving of 6 %, the load shift was only 2 %.

For three months some households were able to try out a tariff which varied according to the time of day. The difference between the two prices was intentionally rather high, as it was intended to give an incentive to use energy during the times that were less expensive. However, the results showed that households using a time-variable tariff only attained a load shift of 2 %. Nevertheless, participants in the variable tariff option saved more energy than households that only received energy consumption feedback. Apparently, time management in users' everyday life can only be changed marginally even with an attractive tariff. This is a disillusion for energy utilities, for they hope to be able to motivate users to use energy preferably when it can be purchased more economically. To obtain these load shifts, innovative technology and automation (Smart Home, Smart Grid), for example tariff-controlled appliances, are required. Still, the tariff led to energy savings that were almost three times as high as in households without a variable tariff. This could be due to the fact that the offered tariff stimulated daily consideration of consumption behavior and therefore led to greater awareness of the energy issue. This explanation was proposed by Dorika Fleissner from Fraunhofer ISE.

An example of the time-variable tariff, which was implemented by some utilities with different spans between the high and low tariffs.



Willingness to pay

There is a willingness to pay for feedback instruments, but it differs strongly depending on the monthly costs.

Another study that was done by ISOE shows that about two-thirds of German consumers are ready to pay for feedback instruments. Among the participants of the field trial - i.e. among people who had been able to gain experience with feedback – the percentage of people willing to pay tends to be a bit higher. Half of the German consumers would accept a price of two euros per month for a web portal with feedback information. At a price of five euros, only 6 % would still accept the service. One quarter of the consumers are ready to pay two euros for written feedback. The following conclusions can be drawn from these results: There is a willingness to pay for feedback instruments but it differs a lot depending on the monthly costs. This leads to distinct strategies for marketing: For a web portal that costs around five euros per month, there is a small, interested, involved and ambitious target group. At a lower monthly contribution of about two euros, approximately half of the users can be reached. However, this requires a broad information campaign, to explain the benefit of feedback instruments. The low willingness to pay for written information can probably be explained by the perception of many users that the costs for a feedback like this are merely the postage costs. Nevertheless there is also a relatively large target group that is willing to pay two euros per month. It might be worth considering the design of different feedback instruments according to interest and involvement of the customers to be used as instruments for customer retention.

Ecological balancing

The decrease in demand first causes CO_2-intensive electricity generation to be reduced. By means of time-variable tariffs and consumption feedback, 3.1 % of CO_2 emissions could be avoided.

The ascertained saving effects lead to a reduced demand for energy and thus to reduced operation of the power plants used for generating electricity. In fossil-fuelled power plants, natural gas, coal or lignite is used as the fuel. On combustion, energy is released and can be transformed into electricity. In this process, CO_2 is released as an exhaust emission. If the use of these power plants is reduced due to a lower energy demand, less CO_2 is emitted as a result.
To find out exactly how much less CO_2 is emitted when the energy demand is reduced by a certain amount, the scientists from the Fraunhofer Institute for Systems and Innovation Research ISI used a simulation model that takes the exact distribution of fuels used for electricity generation in Germany into account. Assuming that savings of 3.7 % are possible throughout all the households in Germany, this would mean a reduction of 1.1 % in the total electricity demand. This is because the household energy demand only accounts for 27 % of the total demand. However, this 1.1 % would result in fewer power plants, especially those burning coal, natural gas or lignite, being operated. The calculations thus show that with the help of consumption feedback, a total amount of 3.6 million t CO_2 per year could be avoided. When combined with time-variable tariffs, the amount is even 9.2 million t CO_2. The avoided amount of CO_2 emission is a little higher than the savings in electricity as the reduced demand first leads to CO_2-intensive power generation being reduced. A decrease of 1.1 % (by feedback) or 2.8 % (by feedback and time-variable tariffs) throughout Germany results in a reduction of the CO_2 emissions caused by electricity generation of 1.2 % or 3.1 % respectively. However, it should be noted that CO_2 emissions caused by power generation represent only a small fraction of the total CO_2 emissions.

Evaluation of the results

Consumers are neither interested in nor do they enjoy wasting energy – the majority considers energy saving to be important and desirable. Feedback supports this attitude. Though only a minority uses the information continuously, the feedback obviously stimulates people to occupy themselves with energy consumption and possibilities to save it. However, none of the ways to use feedback can lead to a marked reduction in consumption without people recognizing appropriate measures to save - this partly works by systematically analyzing the hourly consumption data. It remains unclear, to what extent participants just implement energy-saving measures that they had already known. If this were the case, savings would not be caused directly by feedback and analysis of consumption data. A tangible, though not very large, financial amount of 3.7 % is saved from the perspective of the consumers. Assuming that the average costs of a four-person household are 800 Euro per year, the amount saved would be 28 Euro per year.Measured against the goal

of the Federal Republic of Germany to save 10 % electricity by 2020 in the household sector, the result achieved by Intelliekon is already a contribution to be reckoned with. On the other hand, in summer 2011 the federal government passed a law requiring only households with an energy consumption of more than 6000 kWh per year or new connections to get a smart meter installed – although that kind of meter is the precondition for feedback as provided in Intelliekon. For this reason, it is apparent that in Germany it will be the energy utilities and the system operators that promote the dissemination of smart meters to make sure they meet the minimal requirements made by law. In most cases, a smart metering product with feedback will only be offered to certain target groups which are willing to pay for it. Widespread distribution of the smart measuring systems will at this stage only be realized in a very few areas like Hassfurt, for example.

Conclusions and suggestions

The research team proposes that feedback systems should only be distributed together with accompanying measures to support consumers' energy-saving efforts. Such measures could be, for example, energy-related advisory services in customers' homes (interpretation of the consumption data, instruction and immediate measures) or incentives for economical domestic appliances. Due to the different ways of using feedback, a differentiation of the feedback options for target groups is considered to be necessary. All kinds of smart phone applications (apps) und smart home offers are possibilities, as are services that finance measures with the money saved by energy saving (contracting). Additionally, further non-technical proposals should be made. According to the literature, negotiated agreements are promising. To make the provided information relevant for action, incentives should be set, for example by tariffs to raise consumers' interest and commitment. As people have different needs and wishes, they should be able to choose between different forms of feedback. Even those who do not decide to get a feedback system should nevertheless receive written information on their consumption by post once a month. The research team considers that an area-wide application of smart metering makes sense for two reasons: Firstly because it allows exact and convenient control of the uptake rate and the possible reduction of consumption in households, secondly because of the relevance which smart metering will have for the transformation of the whole energy landscape (intelligent control of the grid) in the future. More adjustments will be required to create appropriate political and legal conditions for arranging economical dissemination of smart meters and intelligent grid control and to assure equitable participation with transparent costs for households.

Glossary

Feedback	The continuous reporting of energy consumption data to the consumer responsible.
Smart Meter	A ”smart“ meter is a meter for energy that displays, according to the definition of § 21b Abs. 3a und 3b EnWG, the energy consumption and the actual time of use to the user. A smart meter can transfer the data automatically to the energy utility.
Web portal	The expression “portal” (lat. porta, ”gate”) in computer science means an application system that is distinguished by the integration of applications, processes and services. A portal offers different functions to its user, for example personalization, security, navigation and user administration. In addition it coordinates the search for and presentation of information.
CO_2	Carbon dioxide is regarded as one of the major gases causing climate change. Therefore there are international efforts to reduce carbon dioxide emissions drastically. Carbon dioxide forms for example when substances containing carbon are burned.

The team of the project Intelliekon

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