INTERACTIVE WEB-BASED GUIDELINE FOR THE EFFICIENCY OF HOUSEHOLD ELECTRIC POWER CONSUMPTION

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The extent to which data analysis capability upgraded with installations of Automatic Meter Readers (AMRs) is quite enormous. We have been studying the possible evaluation of efficiency of individual households' appliances from their hourly power consumptions. The results were fairly reliable at least on the high power consuming domestic appliances level. Now the utilization of available data will be lost in vain unless it is addressed to the respective stakeholders properly. Among these, customers require clear information on their energy bills including saving potentials and comparative consumptions. This interactive web-based guideline attempts to incorporate personalized saving potential calculation results with the delivery of feedback to householders.

Practically there are five most known energy feedback methods namely direct feedback, indirect feedback, inadvertent feedback, utility-controlled feedback and energy audits. Except the energy audit, all the rest uses one way feedback delivery based on the real energy consumption. In the case of energy audits, the consumer gives basic information to an independent software or online application and the relevant feedback is generated. The attempted online calculator in this study is categorized in the energy audits feedback types. With inputs from the user, a yearly electric energy consumption audit and personalized saving potential advices are generated. The following two features of the calculator are extracted after investigation on literature reviews.

1. Personalized feedback based on user input information
2. Consideration of combinational effects of individual appliances

By personalized feedback we mean saving potential calculation specifically tailored to the user. And the combinational effects are interdependencies among individual household appliances based on their presence.

Establishing the web-based application

The purpose of this project was to build electric energy calculator using practical saving potentials and factors evaluated from the AMR metered household electric energy consumptions. The practical factors used in the calculator are evaluated from the data analysis of one year AMR metered consumption and statistical survey of households from Kajaani and Savo areas of central Finland. These factors, listed in Table 1, are obtained from the masters thesis work named 'Energy Efficiency Analysis of Residential Electric End-Uses: Based on Statistical Survey and Hourly Metered Data', which was conducted under ENETE project.

Table 1: Electric energy saving potentials and factors used in the calculator

End-use type	Action	Saving/Factor evaluated
GSHP	Replacing direct electric heating with GSHPs.	Saving of **27.45% to 47.0%** of heating consumption with direct electric heating.
ASHP	Using ASHPs with direct electric heaters as supportive heating.	Reduction in heating consumption by **7.8% to 25.6%.**
Ventilation	Incorporating heat recovery system with Mechanical supply and exhaust ventilation.	An average **13.6%** saving of the total household power consumption.
Thermostat type	Installing programmable thermostat and applying energy star recommended setting.	An average saving of **14.7%** from heating energy consumption.
Thermostat setting	Lowering indoor temperature by 1 degree centigrade during heating season.	An average saving of **3.43%** of total household consumption.
Standby load	NA	An average **46.2 W** per household
Energy saving lamp	Replacing every ILBs by energy saving lamps.	Saving of **13.62% to 17.06%** of total household electric power consumption other than heating.
Supportive heating	Using wood as supportive heating.	Savings of **2.32 kWh** in winter day consumption for each m3 heating wood burning in a year.

Plain html code and java script was used to build the web-based application. The household appliances are grouped in to five main categories.

1. Heating and Ventilation systems
2. Home electronics (Consumer electronics)
3. Kitchen appliances
4. Lighting and utility appliances
5. Office Equipments

Including five pages for the five categories three more pages were also incorporated for home page, calculation result display, and additional information. The snap shots of some of the pages are shown in Figure 1.

Figure 1: Snapshots of calculator web pages

How to use the calculator?

The most important input for the calculation is the heated area of the household from which heating and ventilation consumptions are calculated. The user can also change the default electric energy price value in the heating and ventilation page. To proceed in calculation there are three simple steps.

Step#1: Insert your specific household information in to the online form grouped based on the categories stated above. (Once you inserted values unless you went back to the home page it will be saved and therefore you can make corrections.)

Step#2: For every change you made in the form, the yearly energy consumption and price will be calculated automatically for the category. To make sure of the calculation press calculate before you leave the page.

Step#3: After you finished going through every page of the categorized appliances the report will be ready on the report page. The report page contains:

a. Estimated yearly electric energy consumption of appliance categories.
b. Consumption profile of appliances in the form of bar graph.

c. Estimated saving potentials for the specific house calculated based on the information provided.
d. And finally estimated contribution to heating energy demand from waste heat of appliances.

Also relevant factors used in the calculator are provide in the 'Tips' page for further information.

Calculation result for an example house taken from Kajaani area is presented below. The information needed in the calculator is partially answered using the survey data we have for the respective household. Some additional information was estimated based on related studies.

Table 2: General information of the example house used in the calculation

Profile of example house	
Heated area (sqm)	**121-150**
Primary heating	**Direct electric**
Supportive heating	**Wood**
Ventilation	**Mechanical Exhaust Ventilation with heat recovery**
Actual yearly electric energy consumption (kWh)	**23915**

Table 3: Recommended energy saving actions with their yearly savings for the specific house.

Action	**Saving (kWh/year)**
Using GSHPs instead of direct electric heaters	**8973.45**
Installing programmable thermostat and follow energy star setting recommendation	**1759.07**
Replacing all incandescent bulbs with energy saving lamps	**930.75**
Lowering room temperature by one degree	**410.45**
Unplugging unused appliances to prevent standby consumption	**649.48**

The calculated yearly electric energy consumption of the house was 25667 kWh. It seems more accurate calculation can be achieved when the user him/herself inserts answers to the online questions. Besides the more important issue here is not the estimation of real electric energy consumption but evaluation of weighted saving potentials.

Practicality

The calculator can be implemented by utility companies or service providers in general. The service provider would be responsible to evaluate energy efficiency actions and their practical savings from continual local survey data and AMR metered power consumptions. It then updates the calculation methods based on the results of the analysis.

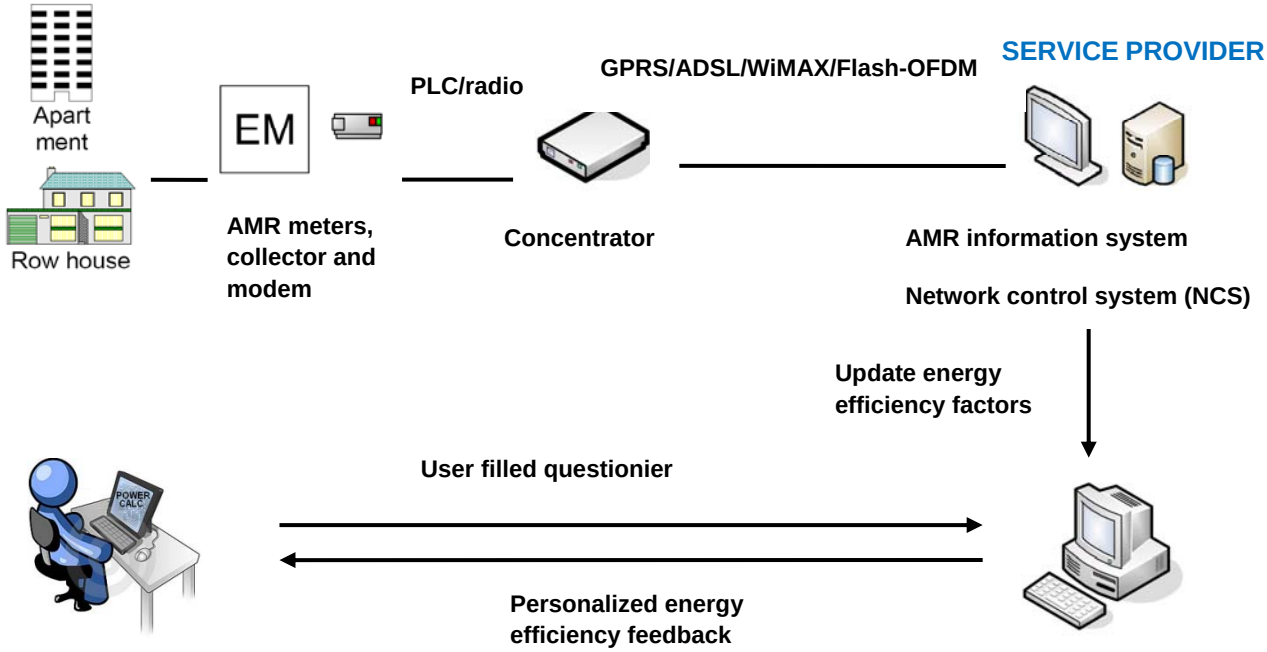

Figure 2: Web-based energy calculator process layout

Once implemented, except for updating of recent results of energy efficiency analysis, the application can run by itself. Practically the whole process of this feedback system is modeled as shown in Figure 2.

Conclusion

The electric energy efficiency analysis based on the AMR metered data is very effective in finding energy saving loopholes and also evaluation of practical savings of the already known efficiency actions. In this project further utilization of the AMR data is implemented for an increase in awareness of efficiency. The method used was generation of personalized energy saving actions using localized factors evaluated from the exemplary households in the neighborhoods.

Effective and directed recommendations can be provided by analyzing personal input information through the web-based calculator. Estimating actual electric energy consumption of households is always in some margin of errors but when savings are calculated, effects of errors are less relevant. Also since the saving actions are quantified, hopefully, people will be initiated for actions. Furthermore, once built, except for updating of factors, there is no need of follow-ups of the web-based application.

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