

Electricity Consumption Management Software Tool for Consumers - MY SMART HOME

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In the introductory part, this paper summarizes the main aspects related to smart homes and home energy management (HEM) technologies and presents several existing HEM solutions. The proposed Electricity consumption management software tool for consumers - MY SMART HOME allows the management of the types of devices that facilitate the monitoring and optimization of electricity consumption: meters, smart devices, and sensors. A process for optimal scheduling of the devices was implemented, through a series of seven steps to be followed by the user. Some reporting solutions, both in graphical and tabular form, for analyzing the initial and optimal consumption per device, consumption place and household are offered.

Keywords: power sector, smart homes, software, energy consumption, optimization.

1 Introduction

Smart homes have been, over the last decade, a priority area related to strategic energy planning. In European Union's Strategic Energy Technology Plan, it is stated that "the Commission's vision for the electricity market aims to deliver a new deal for consumers, smart homes and network, data management and protection" [1].

Smart home technologies consist of a variety of devices such as sensors, monitors, interfaces, appliances that are networked together to enable automation along with localized and remote control of the domestic environment [2]. The results of a survey regarding the perceived benefits and risks of smart home technologies (SHTs) revealed that the survey respondents clearly perceive the main purpose of SHTs to be controlling energy, heating and appliances, indicating that the smart home is mostly seen through an energy management lens [3].

The emergence of electrical devices for end consumers, whose operation can be

programmed, has led to increased interest in IT solutions for consumer management at the household level. A study presented in [4] explored a vast range of home energy management (HEM) technologies on the market and identified how their functionalities may support energy reductions and load shifting opportunities. The aim of the study was to identify the technical capabilities and potential for HEM products to deliver savings, hence considerably increasing user's understanding on how HEM technologies could be, in fact, leveraged for energy savings.

As stated in [5], the popularity of HEMs has been substantially in recent years due to a series of advantages offered by smart phone and tablet connectivity, such as high accessibility, convenience, and affordability. Also, it presents an introduction and description for the overview of HEMs architecture, as well as a detailed investigation on the functions of renewable energy, home appliances and demand response in HEMs. It is shown that solar energy is a main contributor to home energy

consumption, while the wind, biomass and geo-thermal energy often contribute relatively less and limited due to urban geography and climate factors.

The approach presented in [6] uses price-based demand response (DR) programs, which pursue the involvement of end-user's participation in the distribution system operation. Since the residential demand is a significant portion of the total system load, residential DR programs are important from the system operator's perspective. The basis of DR programs is the intention of the system operator to create an electricity tariff or an incentive in order to encourage customers to voluntarily adjust their regular electrical consumption patterns. This method is based on prioritizing the operation of controllable appliances from the customer's perspective by considering the value of lost load of each appliance, electricity tariffs, and operational constraints of appliances. The output of the proposed HEM would be the optimum scheduling of household electrical demand. Furthermore, the research presented in [7], indicates that in controlling end-user assets, independently taken decisions can cause undesired effects such as rebound peaks, contingencies, and instabilities in the network. Also, it reviews, compares, and classifies approaches related to demand-side management and DR in a single household and concepts of coordinating mechanisms in a neighbourhood area. It is shown that recent research in the field reveal that the coordination of energy management in multiple households can bring benefits to both the customer and the system operator.

In the Energy Management System for smart homes proposed by [8] each home device is interfaced with a data acquisition module that is an IoT object with a unique IP address resulting in a large mesh wireless network of devices. There is a dedicated module which collects energy consumption data from

each device of each smart home. Further, data are transmitted to a centralized server for additional processing and analysis using off-the-shelf Business Intelligence (BI) and Big Data analytics software packages. In order to validate the proposed system, heating, ventilation and air conditioning units have been used as a case study.

2 Presentation of usage options

The paper presents the main functionalities and characteristics of a proposed Electricity consumption management software tool for consumers - MY SMART HOME. The tool enables the management of various types of devices that facilitate the monitoring and optimization of electricity consumption in a smart home: meters, smart devices, and sensors.

Two sections are used in the main page of the prototype for general settings purposes (as in figure 1): a section for editing personal data and a section that allows the management of consumption places.

The personal data editing section allows the editing and updating of consumer data. Several details about a consumer can be entered: data regarding the type of consumer (which is chosen from a predefined list), the customer's name (required field), postal and email addresses, contact telephone number, bank account and location.

The second section of the first page allows the management of consumption places associated with a consumer. These are highlighted in the following figure. The user has the possibility to add, modify or delete information about a certain consumption place. This information includes: ID of the place of consumption, a suggestive name, the start date (which must be entered in the format highlighted when accessing the field), the period of validity of the contract, expressed in months, details of the type of consumption place, consumption location and energy supplier. For the last four fields, the user will be able to select the entered data via a list of values.

The user can add, update, or delete a

consumption place. Also, on this page, the user can view the consumption places that he has entered sorted according to the desired criteria. Thus, by placing the mouse over the name of a field in the list, two buttons will become visible that allow ascending data sorting or

descending sorting of data depending on the values of that field. To access the electrical devices associated with a consumption place, the user selects the desired consumption place of from the list and then clicks on the *View details* option on the left side of the window.

Managementul locurilor de consum

Pentru a accesa dispozitivele selectati locul de consum corespunzator:

Dispozitive electrice asociate	ID loc consum	Denumire	Data de inceput	Valabilitate contract (tuni)	Detalii	Localizare	Furnizor	
View details	ASE_2017	ASE SALA 2017	1/1/2015	36	COURSE CLASS	Bucuresti, Romania, Bucuresti	ASE Supplier	Salvati
View details	ASE_2017B	ASE BIROUL 2017B	1/1/2015	36	OFFICE	Bucuresti, Romania, Bucuresti	ASE Supplier	Salvati
View details	ASE_2017C	ASE BIROUL 2017C	1/1/2015	36	OFFICE	Bucuresti, Romania, Bucuresti	ASE Supplier	Salvati
View details	ASE_2209	ASE SALA 2209	1/1/2015	36	COURSE CLASS	Bucuresti, Romania, Bucuresti	ASE Supplier	Salvati

Salvarea datelor se face in 2 pasi: 1. Salvati 2. Confirmati: Daca va razganditi, puteti Anula!

Adauga loc de consum | Sterge loc de consum | Confirmati | Anulati

Fig. 1. Home page – Section for consumption place management

A window will be displayed in which the facilities offered by the module for managing a consumption place can be used. These facilities can be accessed via tabs a series of different tabs dedicated to a certain component of the module, as follows:

- Smart meters
- Smart devices
- Sensors
- Tariffs
- Optimal programming of devices
- Consumption distribution analysis
- Supplier recommendations
- Devices control

3 Smart meters management

The first tab, Smart meters offers, through the Meter administration section, the possibility to manage the meters

associated with a consumption place. For a meter, information about the installation date and installation start date is stored, type (is selected from a list of values), maximum rated power, current specification, model, ip, mac, and gateway. It is possible to add, update and delete information about a smart meter.

The user can access information on electricity consumption evolution and total generation over time in a graphical form. The user selects, by the means of a calendar, the start date, and the end date for which he wants to view the consumption information. A graph (shown in the figure 2) on the consumption evolution and total generation over time will be displayed.

The vertical axis of the graph shows the active power consumed and (if applicable) the active power generated, and the horizontal axis shows time intervals of 15 minutes for the previously selected period. By placing the mouse over the surface of the graph and using the scroll wheel of the

mouse, the user can view the evolution of consumption for the entire period

previously

selected.

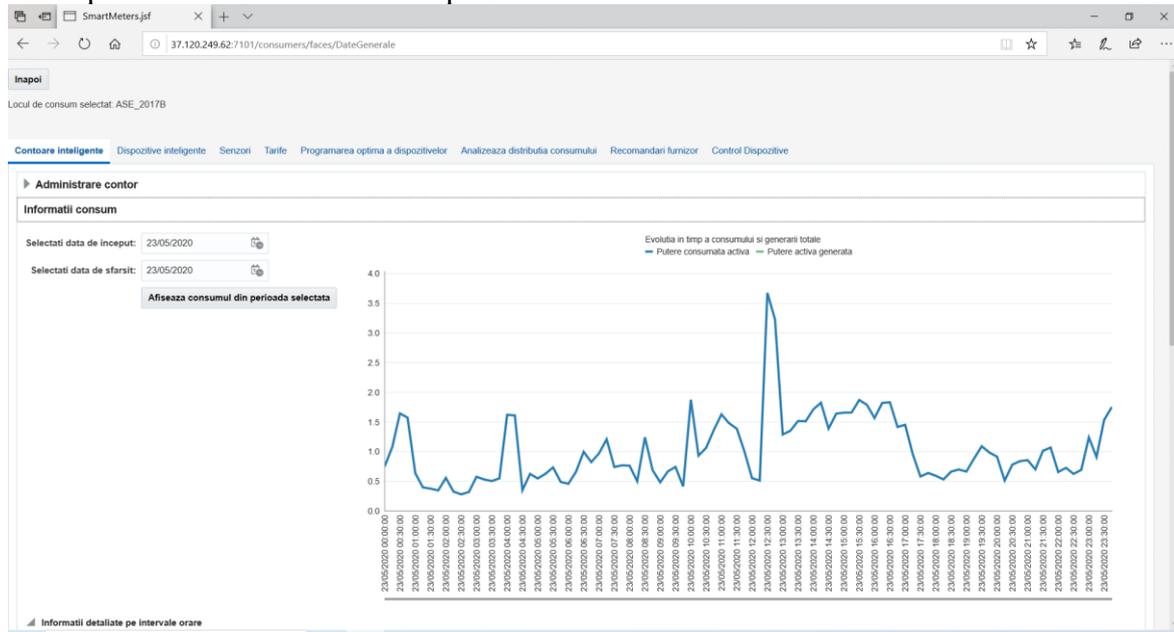


Fig. 2. Consumption information section from Smart Meters tab

Detailed information on consumption, are also presented in tabular form). In the table shown in figure 3, the user can view information on: day and time, meter ID that recorded the measurements, power consumed and generated, status, validity, measurements on voltage, current and total power, and possible error codes. The data in this table can be sorted by any of

its fields, except Day/Time. By placing the mouse over the name of a field in the list, two buttons become visible that allow ascending data sorting or descending sorting of data depending on the values of that field. Also, once data are sorted, their visual representation will be updated (as shown in figure 3).

The screenshot shows a web browser window with the URL 37.120.249.62:7101/consumers/faces/DateGenerale. The page title is 'SmartMeters.jsf'. Below the browser window, there is a navigation menu with options like 'Contoare inteligente', 'Dispozitive inteligente', 'Senzori', 'Tarife', etc. The main content area is titled 'Informatii detaliate pe intervale orare'. It shows a table with the following columns: 'Ziua/Ora', 'ID Contor', 'Putere consumata activa', 'Putere activa generata', 'Status', 'Valid', 'Tensiune (Mv)', 'Curent (Ma)', 'Putere totala (Wh)', 'Cod eroare 1', and 'Cod Eroare 2'. The table contains 24 rows of data, one for each 15-minute interval from 00:00:00 to 06:00:00 on 23/05/2020. The 'Putere consumata activa' column shows values ranging from 0.35 to 1.646. The 'Putere activa generata' column is mostly empty, indicating zero or negligible generation. The 'Status' column is 'ACTUAL' for all rows, and the 'Valid' column is 'YES' for all rows. The 'Tensiune (Mv)' and 'Curent (Ma)' columns are also empty. The 'Putere totala (Wh)' column is empty. The 'Cod eroare 1' and 'Cod Eroare 2' columns are empty.

Ziua/Ora	ID Contor	Putere consumata activa	Putere activa generata	Status	Valid	Tensiune (Mv)	Curent (Ma)	Putere totala (Wh)	Cod eroare 1	Cod Eroare 2
23/05/2020 00:00:00	12	0.751		ACTUAL	YES					
23/05/2020 00:15:00	12	1.08		ACTUAL	YES					
23/05/2020 00:30:00	12	1.646		ACTUAL	YES					
23/05/2020 00:45:00	12	1.575		ACTUAL	YES					
23/05/2020 01:00:00	12	0.638		ACTUAL	YES					
23/05/2020 01:15:00	12	0.399		ACTUAL	YES					
23/05/2020 01:30:00	12	0.379		ACTUAL	YES					
23/05/2020 01:45:00	12	0.35		ACTUAL	YES					
23/05/2020 02:00:00	12	0.56		ACTUAL	YES					
23/05/2020 02:15:00	12	0.329		ACTUAL	YES					
23/05/2020 02:30:00	12	0.283		ACTUAL	YES					
23/05/2020 02:45:00	12	0.323		ACTUAL	YES					
23/05/2020 03:00:00	12	0.578		ACTUAL	YES					
23/05/2020 03:15:00	12	0.534		ACTUAL	YES					
23/05/2020 03:30:00	12	0.507		ACTUAL	YES					
23/05/2020 03:45:00	12	0.552		ACTUAL	YES					
23/05/2020 04:00:00	12	1.623		ACTUAL	YES					
23/05/2020 04:15:00	12	1.812		ACTUAL	YES					
23/05/2020 04:30:00	12	0.352		ACTUAL	YES					
23/05/2020 04:45:00	12	0.627		ACTUAL	YES					
23/05/2020 05:00:00	12	0.551		ACTUAL	YES					
23/05/2020 05:15:00	12	0.628		ACTUAL	YES					
23/05/2020 05:30:00	12	0.736		ACTUAL	YES					
23/05/2020 05:45:00	12	0.492		ACTUAL	YES					
23/05/2020 06:00:00	12	0.461		ACTUAL	YES					

Fig. 3. Table of detailed information by time intervals for a device (meter)

The text boxes placed above the table

fields help to filter the data. Thus, the value

according to which you want to filter the data of a field will be placed in the corresponding text box and then Enter key will be pressed. Data can be filtered simultaneously by multi-field values.

4 Smart devices management

The Smart devices tab allows the user to manage smart devices assigned to a

consumer location (section Device management) and is shown in the following figure. It should be noted that the consumption place was previously selected on the first page of the module. It is also possible to view information about the consumption of a smart device in section Device consumption information.

	Dispozitiv	Model	Descriere	Mac	Producator	Status	ID loc consum	Serial No	Putere nominala consumata	Specificatii curent	Tip	Denumire	Alia
Detalii	ASE_2017B_1	Microwave	Microwave				ASE_2017B		2		Microwave	Microwave 2017	Mic
Detalii	ASE_2017B_2	Vacuum Cleaner	Vacuum Cleaner				ASE_2017B		0.024		Accumulator De	Vacuum Cleaner	Vac
Detalii	ASE_2017B_3	Light1	Light1				ASE_2017B		2		Light	Light	Ligh
Detalii	ASE_2017B_4	Light2	Light				ASE_2017B		2		Light	Light	Ligh
Detalii	ASE_2017B_5	Light	Light				ASE_2017B		2		Light	Light	Ligh
Detalii	ASE_2017B_T_...	Consum backgr	Consum backgr				ASE_2017B		5		Neprogramabil	Consum backgr	Cor

Fig. 4. Smart devices tab overview - Device management section

The following information about a smart device can be stored: device name (cannot be updated), model, description, Mac, manufacturer, status, consumption location ID, serial number, rated power consumption, current specifications, type, extended name, alias, control type (selected from a list), if controllable (selected from a list), under control type, power generated, device ID, IS Total.

In this window the user can add, modify, or delete smart devices associated with a consumption place.

Sorting is allowed according to any of the fields. At this level it is also possible to filter data, using the text boxes placed above the fields. By clicking the *Details* link on the left side of the smart device row, the user can add additional details

about a smart device.

5 Sensors management

The Sensors tab, presented in the figure below, allows the management of the sensors associated with a consumption place.

It is possible to store the following sensor related information: name, description, current specifications, installation date and monitoring start date, device ID, MAC, model, maximum rated power, type, gateway.

The user can add, modify, or delete sensor devices associated with the selected consumption place.

At the same time, the data in the sensor records can be sorted according to any of its fields, using the buttons that appear next to the field names in the table header.

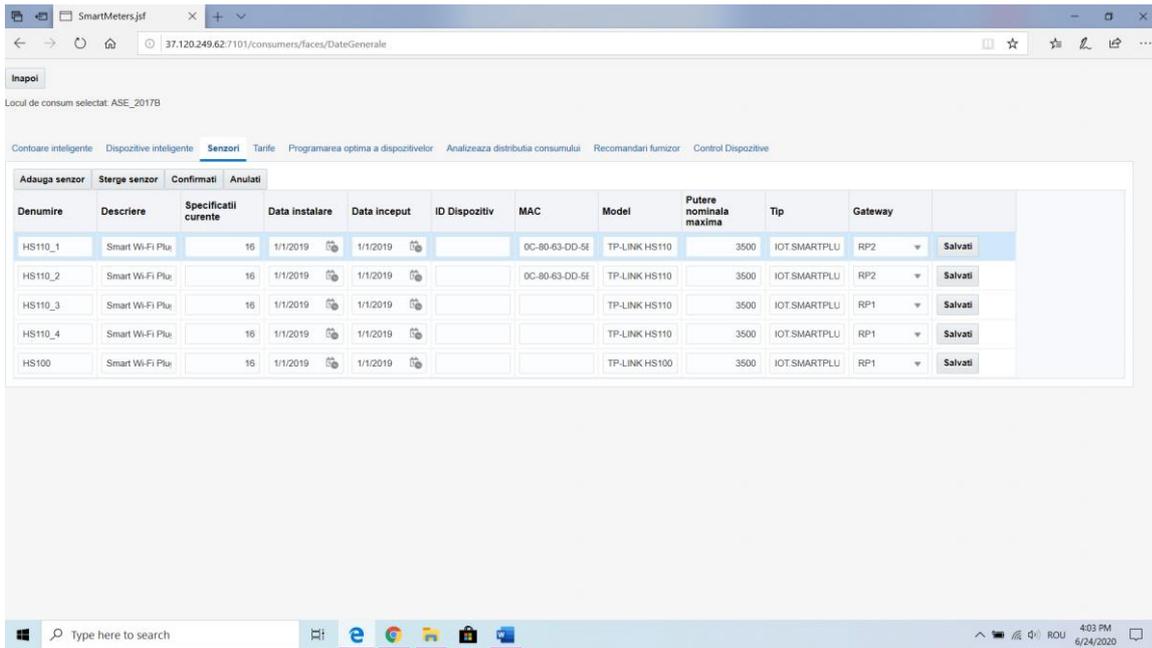


Fig. 5. Sensors information management tab

6 Tariffs management

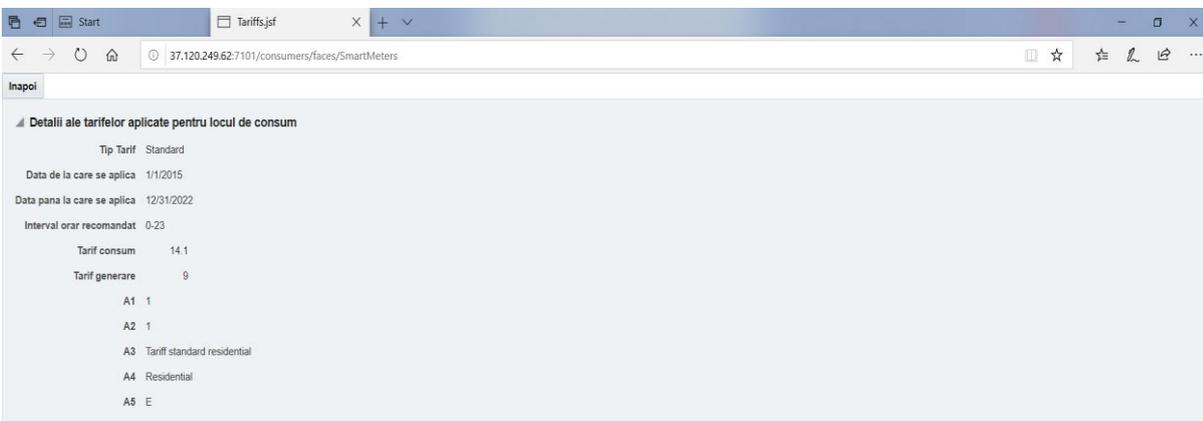
Figure 6a shows the Tariffs tab, having the role of allowing the visualization of the electricity tariffs that will be applied for the respective consumption place. The start date and end date for which a tariff plan applies are displayed, as well as the

applicable time slot.

By accessing the Plan details link on the left side of the information regarding a tariff plan, other details can be viewed, such as those related to the tariff applied for consumption or for generation (Figure 6b).



a)



b)

Fig. 6. Tariffs applied to a consumption place

7 Optimal scheduling of devices

The Optimal device scheduling tab allows the user to program smart devices as well as to optimize their operating schedule. The page also includes an information section showing the steps that must be followed to obtain an optimal device scheduling.

To display existing smart device schedules, the user must select the schedule day by directly entering a value in the specified format or using the calendar that appears. The scheduling of

smart devices for the selected place of consumption will be displayed, if any (figure 7).

The smart device view section presented in the next figure displays the following information about a device: the date it was scheduled, device ID, name, type, start time, stop time, vendor estimate, power generated estimated power, estimated power consumption, degree of flexibility, rated power, whether rated power is used and whether the program has been transmitted to the equipment.

The screenshot shows a web application interface for 'SmartMeters'. The main content area is titled 'Programarea optima a dispozitivelor'. It includes an 'Information' section with instructions for optimization steps and buttons for 'Confirma parametrii', 'Optimizeaza programul de functionare', 'Confirma programul optim', and 'Trimite programul catre dispozitive'. Below this is a table titled 'Vizualizeaza programarea dispozitivelor' with columns for 'Data programarii', 'ID Dispozitiv', 'Denumire', 'Tip', 'Ora de pornire', 'Ora de oprire', 'Estimat de furnizor', 'Putere generata estimata', 'Putere consumata estimata', 'Grad flexibilitate', 'Putere nominala', 'Utilizeaza puterea nominala', and 'Transmis catre echipament'.

Data programarii	ID Dispozitiv	Denumire	Tip	Ora de pornire	Ora de oprire	Estimat de furnizor	Putere generata estimata	Putere consumata estimata	Grad flexibilitate	Putere nominala	Utilizeaza puterea nominala	Transmis catre echipament
5/23/2020	ASE_2017B_1	Microwave 2017B	S	2020-05-23 18:...	2020-05-23 20:...	1			2	0	2	1
5/23/2020	ASE_2017B_2	Vacuum Clean...	I	2020-05-23 20:...	2020-05-23 23:...	1		0.024	1	0.024		1
5/23/2020	ASE_2017B_3	Light	I	2020-05-23 19:...	2020-05-23 22:...	1		2	1	2		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 00:...	2020-05-23 01:...	1		1.022	0	5		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 01:...	2020-05-23 02:...	1		0.827	0	5		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 02:...	2020-05-23 03:...	1		0.449	0	5		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 03:...	2020-05-23 04:...	1		0.462	0	5		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 04:...	2020-05-23 05:...	1		0.638	0	5		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 05:...	2020-05-23 06:...	1		0.96	0	5		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 06:...	2020-05-23 07:...	1		1.147	0	5		1
5/23/2020	ASE_2017B_T_...	Consum backgr...	TNP	2020-05-23 07:...	2020-05-23 08:...	1		1.406	0	5		1

Fig. 7. View the scheduling of the devices for a consumption place

The functionalities offered for the optimal scheduling of the devices will be described, following the seven steps specified in the information section.

Step 1. Program the devices

Using the device scheduling section, presented in the figure 8, involves selecting the smart device for which the scheduling is done. It is followed by: selecting the scheduling date, start time and stop time, selecting options to use the rated or estimated power of the supplier, enter values for the estimated consumed and generated powers and select the degree of flexibility by choosing one of the available options (Fixed, Reprogrammable at home or Reprogrammable by the supplier).

Also, the user may add a new schedule for a device, delete the currently displayed schedule, or browse existing schedules.

Step 2. Confirm the parameters

The user confirms the required parameters for smart devices scheduling. After confirming the parameters, a message is displayed specifying the day and place of consumption for which the parameters have been confirmed.

Step 3. Optimize the schedule

The user chooses the option to optimize the schedule. After this, a message is displayed stating that the optimization was successful and that the optimization results can be viewed in the corresponding section.

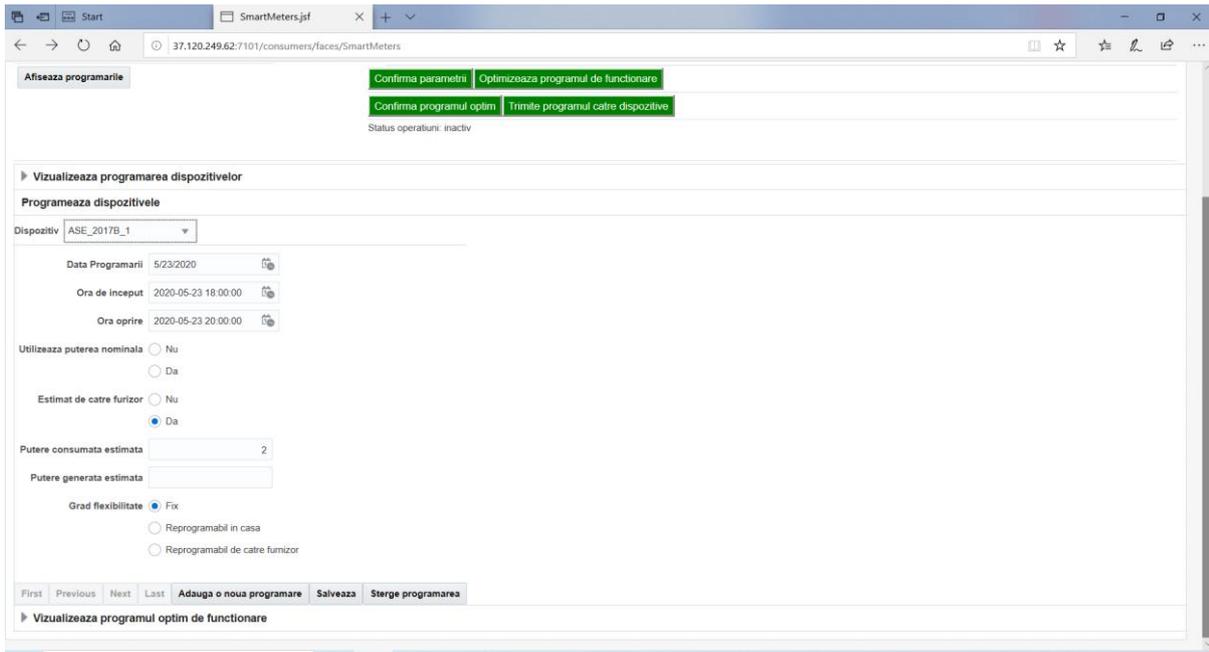


Fig. 8. Smart devices scheduling section

Step 4. View the optimal scheduling

The module offers the possibility to view the optimal schedule in either graphical or tabular form.

The graphical form (presented in figure 9) shows two graphs that reflect, for each of the 24 hours of the selected day, the comparative evolution of the total initial consumption and the optimal total

consumption, respectively the comparative evolution of the initial total costs and the optimal total costs.

The tabular form allows the user to view the day and time for which the direct costs are displayed, the name of the tariff, the tariff type, the consumption and generation tariff for each hour, as well as the total initial and post-optimization costs and consumptions.

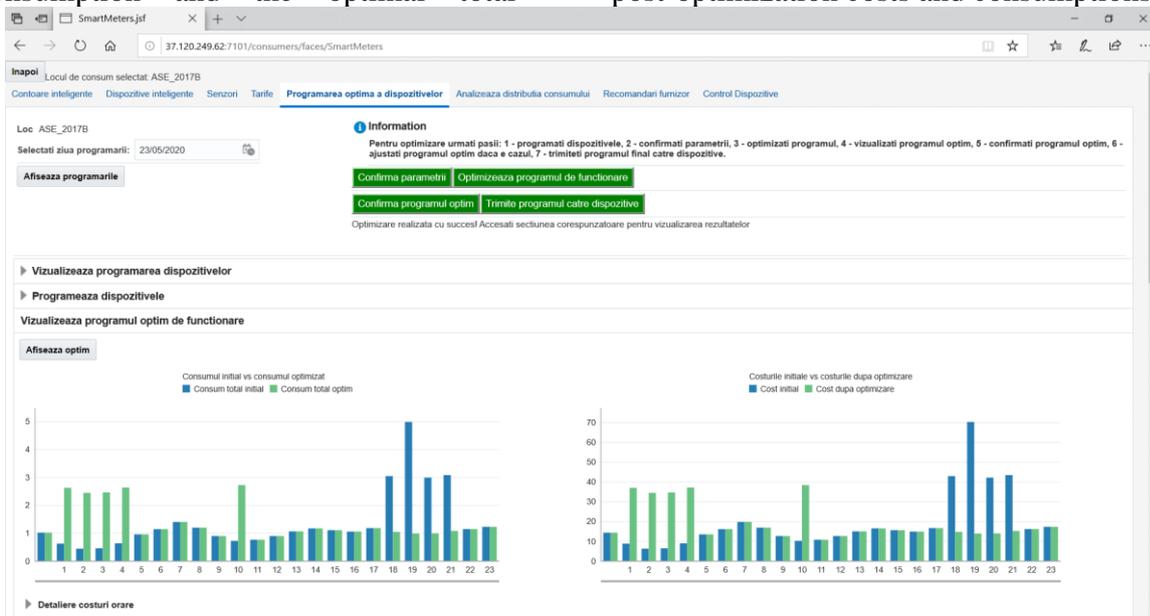


Fig. 9. Graphical representations regarding the evolution of initial costs / consumptions versus optimized costs / consumptions

The module provides the facility to analyze the optimal operating schedule

for smart devices, in terms of consumption places of the house.

As seen in figure 10, presentations in graphical form and in tabular form are available in the corresponding section for optimal scheduling at house level.

Two graphs allow the visualization of the initial consumption for each device and of the consumption optimized per device for every hour of the day for which the optimization was performed. The adjacent layout of the graphs offers the user the possibility to perform a comparative analysis between the initial situation and the one after optimization.

Also, the table in the same figure offers the possibility to view in detail the hourly consumption, from the analyzed day, for each smart device identified in the selected home. The following fields can be viewed in the table: analyzed day, time, device ID, start date, stop date,

estimated by the vendor, estimated and consumed overall power, optimal consumption, degree of flexibility, scheduling date, rated power usage and transmitted in fog.

The table provides some advanced viewing options via the *View* menu. Thus, by selecting the *Columns* option, the user can choose to display all the columns of the table (*Show All* option) or can check only certain columns.

There is also the option to arrange the columns of a table in the order you want, by clicking on the *View* button followed by selecting the *Reorder Columns...* option from the menu. A window containing all the visible columns of the table will be displayed. The order in which the columns appear in this list is also the order in which they will be displayed in the table.

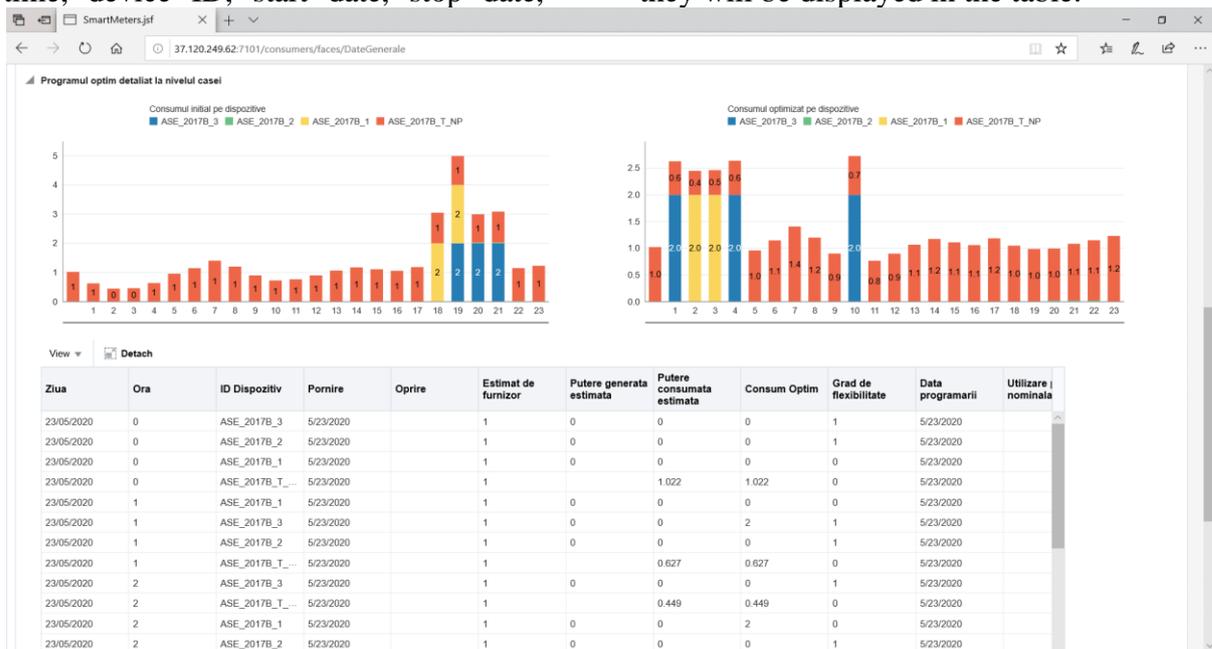


Fig. 10. Graphical view of the initial and optimal consumption per device

Step 5. Confirm the optimal schedule

After the user confirms the optimal schedule, a message is displayed specifying that the optimal program for the previously selected day and place of consumption has been confirmed.

Step 6. Adjust the optimal schedule, if necessary

If the user wishes, he can return to Step 1. Program the devices to change the

optimal scheduling of the devices.

Step 7. Send the final schedule to the devices

The user sends the final schedule to the devices. After this action, a message is displayed stating that the devices have been scheduled for the previously selected day and consumption place.

After completing these seven steps, the result is an optimal consumption schedule at the household level, which can be customized.

8 Consumption distribution analysis

Consumption distribution analysis tab allows the visualization, in graphical and tabular form, of the initial and optimal consumption on types of smart devices. The user must select the day for which the consumption distribution is to be analyzed.

Two graphs (shown in figure 11) allow the visualization of the initial

consumption by types of devices and the optimal consumption by types of devices for each hour of the previously selected day.

Each type of device is highlighted with a distinct color in the bar graphs. The adjacent arrangement of the graphs offers the user the possibility to perform a comparative analysis between the initial and the optimal consumption by types of devices.

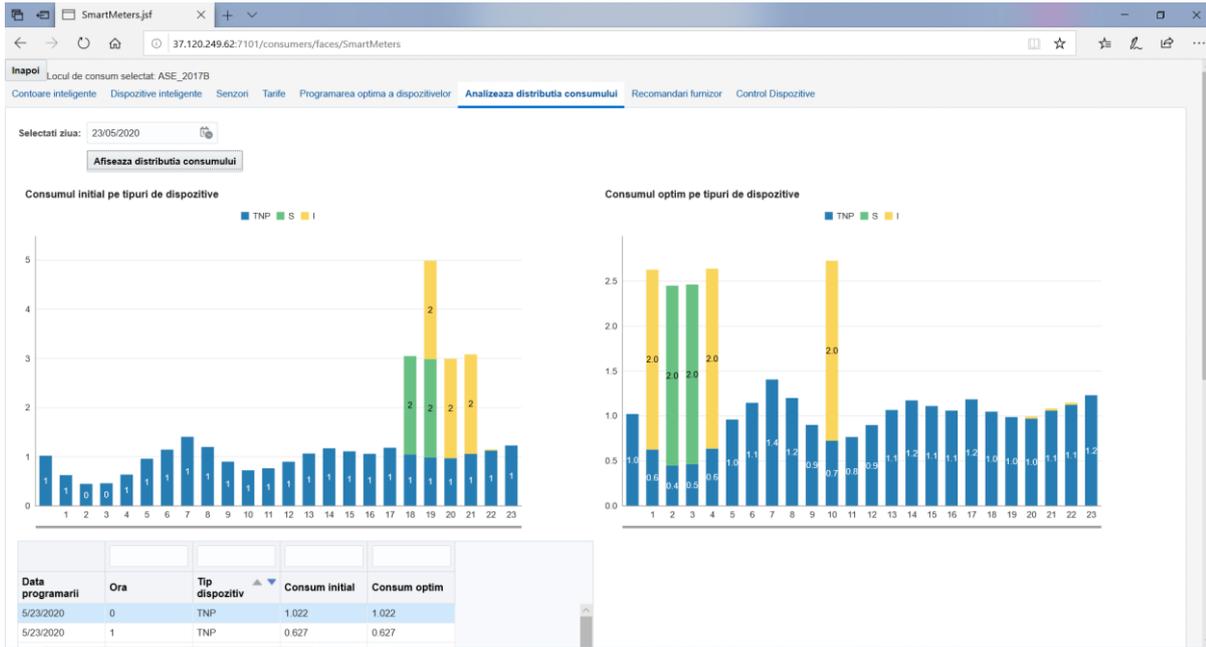


Fig. 11. Graphical view of initial and optimal consumption by device types

The tabular view from figure 12 below, offers the possibility to view in detail the initial and optimal hourly consumption for the analyzed day, aggregated on each

type of smart device identified in that home. The table can display the date of scheduling, time, device type, initial consumption, and optimal consumption.

Data programarii	Ora	Tip dispozitiv	Consum initial	Consum optim
5/23/2020	17	TNP	1.185	1.185
5/23/2020	18	TNP	1.048	1.048
5/23/2020	19	TNP	0.988	0.988
5/23/2020	20	TNP	0.971	0.971
5/23/2020	21	TNP	1.06	1.06
5/23/2020	22	TNP	1.125	1.125
5/23/2020	23	TNP	1.231	1.231
5/23/2020	0	S	0	0
5/23/2020	1	S	0	0
5/23/2020	2	S	0	2

Fig. 12. Visualization in tabular form of the initial and optimal consumption by types of devices

The meaning of the acronyms in figure 11 and figure 12 is as follows:

- TNP - total consumption of non-programmable devices (devices that cannot be optimized);
- S - total consumption of reprogrammable devices (shiftable), with the restriction that the operating cycle must be taken into account (for example, the washing machine can be moved to another time only by respecting its operating cycle);
- I - total consumption of devices that can be interrupted and resume their operating cycle at another time (for

example the charging vacuum cleaner).

9 Devices control

In the devices control tab presented in figure 13, the user can view the current schedules of a selected device for a certain day, in tabular form.

Information about scheduling a device includes scheduling date, device ID, start and stop time, estimated by the vendor, estimated power consumed and generated, degree of flexibility, if using nominal power, and SentToFog.

This section allows the user to add a new schedule for the device, to delete a schedule and to turn on or off the selected device.

The screenshot shows a web browser window with the URL 37.120.249.62:7101/consumers/faces/SmartMeters. The page title is 'Inapoi' and the selected location is 'Locul de consum selectat: ASE_2017B'. The 'Control Dispozitive' tab is active. The interface includes a dropdown for 'Dispozitiv' (ASE_2017B_1) and a date selector for '23/05/2020'. Below these are buttons for 'Afiseaza programările curente', 'Porneste dispozitivul', and 'Opreste dispozitivul'. A table displays the following data:

Data Programarii	ID Dispozitiv	Ora de Inceput	Ora oprire	Estimat de catre furnizor	Putere consumata estimata	Putere generata estimata	Grad flexibilitate	Utilizeaza puterea nominala	SentToFog	Salvare programare	Stergere
5/23/2020	ASE_2017B_1	2020-05-23 02:00	2020-05-23 04:00	1	2		0		1	Salveaza	Sterge

At the bottom of the table, there are buttons for 'Adauga programare', 'Confirma', and 'Trimite programul către dispozitive'.

Fig. 13. Presentation of Devices control tab

10 Conclusions

Smart homes are a subject of great interest for research in the fields of information technology and smart devices. Efficiency of electricity consumption at the level of a household is an important component regarding the management of smart homes.

The proposed software solution, Electricity Consumption Management Module for Consumers - My Smart Home, offers an integrated approach that deals with the management of various

elements related to electricity consumption such as smart meters, smart devices, sensors, and tariffs.

One of the most important functionalities offered by the module is the optimal schedule of devices, allowing the user to program smart devices along with optimizing their functioning schedule.

For decision support proposes, the module provides various representations that illustrate initial costs/consumptions versus optimized costs/consumptions per device, consumption place or household.

11 Acknowledgment

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