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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Energy efficiency, smart energy and green data centres

Smart energy solutions for city and home applications

Recommendation ITU-T L.1383

ITU-T

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.1383

Smart energy solutions for city and home applications

Summary

Recommendation ITU-T L.1383 focuses on smart energy solutions in different application scenarios facilitating energy saving and carbon emission reduction. Besides their application in the field of ICT, such as in base stations, data centres and telecom centres, smart energy solutions have been applied in cities and homes as an advanced update to ICTs. Cities play a different role in different parts of the world. With the development of smart energy technologies, it is becoming possible to answer key issues in cities worldwide, prompted by the urgent necessity of GHG emissions reduction.

This Recommendation includes specific smart energy applications in cities and homes, such as energy sources and energy management functions.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.1383	2021-10-07	5	11.1002/1000/14719

Keywords

Cities, home, photovoltaic, renewable energy, smart energy, wind.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Smart energy solutions for city and home applications

1 Scope

This Recommendation provides smart energy solutions that boost energy efficiency and reduce carbon emissions in different cities and home applications, namely:

– City applications, including those in the business district, community, industrial park, transportation network and municipal area.
– Home applications including household appliances, electric vehicle charging, power dual-way trading and habit training of energy use.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1220] Recommendation ITU-T L.1220 (2017), *Innovative energy storage technology for stationary use – Part 1: Overview of energy storage.*

[ITU-T L.1221] Recommendation ITU-T L.1221 (2018), *Innovative energy storage technology for stationary use – Part 2: Battery.*

[ITU-T L.1305] Recommendation ITU-T L.1305 (2019), *Data centre infrastructure management system based on big data and artificial intelligence technology*.

[ITU-T L.1380] Recommendation ITU-T L.1380 (2019), *Smart energy solution for telecom sites.*

[ITU-T L.1381] Recommendation ITU-T L.1381 (2020), *Smart energy solutions for data centres.*

[ITU-T L.1382] Recommendation ITU-T L.1382 (2020), *Smart energy solutions for telecommunication rooms.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 reliability [b-ITU-T L.1022]: Probability that a product functions as required under given conditions, including maintenance, for a given duration without failure.

NOTE 1 – The intended function(s) and given conditions are described in the user instructions provided with the product.

NOTE 2 – Duration can be expressed in units appropriate to the part or product concerned, e.g., calendar time, operating cycles, distance run, etc., and the units should always be clearly stated.

3.1.2 smart energy [ITU-T L.1380]: A power system that uses a smart control technique system to autonomously combine various energy supplies according to the working conditions of power supply and load.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 business district: A kind of area that is mainly composed of office buildings, malls, restaurants, etc.

3.2.2 electric transportation network: A kind of network system that is composed of electric public transportation (bus, taxi, subway), electric private transportation and auxiliary infrastructure (charging station, charging pile, battery changing devices, etc.)

3.2.3 industrial park: A kind of area that is mainly composed of different kinds of factories (such as gasoline manufacturing, cement manufacturing, fabric manufacturing and iron mine manufacturing factories).

3.2.4 municipal area: A kind of area that is mainly composed of governmental buildings (such as energy administration, ministry of finance).

3.2.5 residential community: A kind of area that is mainly composed of residences, parks, hospitals, supermarkets, schools, etc.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

GHG Greenhouse Gas

ICT Information and Communication Technology

5 Conventions

None.

6 Smart energy application for cities

In some cases, the level of energy efficiency of city applications cannot be further optimized due to a lack of Information and Communication Technology (ICT). Therefore, it is crucial that cities take a proactive stance in improving the uptake of ICTs. They are key enablers for driving smart energy solutions in city applications. By facilitating the adoption of clean energy, regional customization, network communication and the Internet of Things, energy utilities in urban areas can be improved and optimized. Smart energy solutions can also promote conversion to all kinds of renewable energy sources such as solar, wind power, electric power and chemical power, increase the uptake of clean energy for electric power generation, optimize energy feeding structure and improve overall energy efficiency. Distinguished by their specific functions, smart energy solutions can be applied to five keys domains of a city, including the business district, community, industrial park, electric transportation network and municipal area.

6.1 Smart energy applications in business districts

Buildings in a business district consume high volume of energy owing to their complexities and high number of layers. Smart energy applications can improve the energy performance of such buildings by facilitating real-time monitoring and converting energy data into energy-saving functions.

Figure 1 shows a smart energy system in an office building in a business district. By facilitating network interconnection using smart energy solutions such as big data technology and smart sensors, real-time and past data of energy consumption can be collected. Once the necessary data has been collected, smart control of an energy utility can then carry out analysis for optimization. The results can apply to each component according to their specific need. For example, a smart system can recognize energy waste in a specific room and automatically execute a remote power-off function to save energy. Meanwhile, a photovoltaic module can also be applied to the surface of buildings to power them with renewable energy, easing the reliance on the traditional grid.

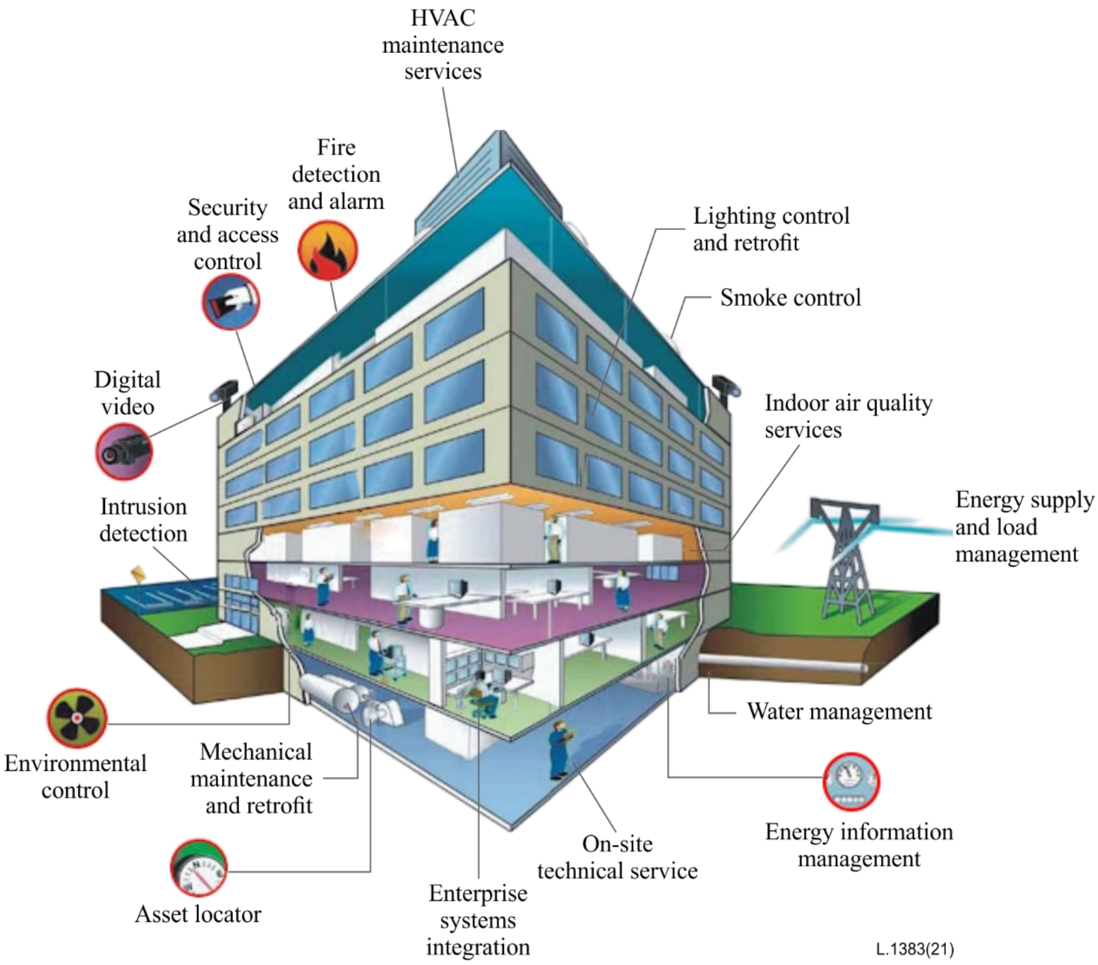

Figure 1 – Smart Energy in a Business Building (the elements shown are applicable to buildings in business districts such as offices and malls)

In addition, power reliability is also important owing to the high density of people in the business district. The workload of operation and maintenance for relevant staff is high. After application of smart energy, potential reliability problems can be figured out in time and emerging reliability problems can be automatically solved. For instance, it is common that a large number of electric devices with different voltage levels, such as $220V_{ac}$, $230V_{ac}$, $380V_{ac}$, $400V_{ac}$, $48V_{dc}$ and $12V_{dc}$, exist within a single office building. In such a case, the power distribution system would be prone to overload due to the various voltage levels and large number of devices. Under traditional operation and maintenance, the maintenance staff would need to check all power supply and utility devices layer by layer, which is a time consuming process, and it could be difficult to identify the point of failure in an emergency. With smart energy solutions, each power device can be automatically monitored and can perform self-check and self-solving in a very short space of time. With the support of big data analysis and AI technology, if there are potential problems, the relevant information can be sent to maintenance staff through a remote control application, so they can eliminate the potential problem by applying different smart solutions.

6.2 Smart energy applications in residential communities

Communities are an important part of cities. With renewable energy continuing to advance at a fast pace, solar and wind power are gradually being more commonly used for power generation. Meanwhile, power storage systems can be used to stabilize the fluctuation of power generation. The structure of a smart energy system in a residential community is shown in Figure 2.

Different time slots entail different levels of energy consumption. For example, the level of energy consumption is relatively low in the morning in comparison with the evening. With smart energy solutions, the input power from wind turbine and photovoltaic modules can be stored in a battery system for future use (see [ITU-T L.1220] and [ITU-T L.1221] for details). In the case of critical infrastructure, such as hospitals, schools and supermarkets, smart energy systems can automatically adjust the proportion of output power based on energy demand [b-Mengdi Wang]. At night-time, the stored wind and solar electric power can be dynamically used based on real-time data of power need. At the same time, the connected electric vehicle charging piles can carry out dual-way power trading. On one side, an electric vehicle low in power can get lower-cost electricity and on the other side, an electric vehicle battery with higher capacity can feed power to the grid to sell energy.

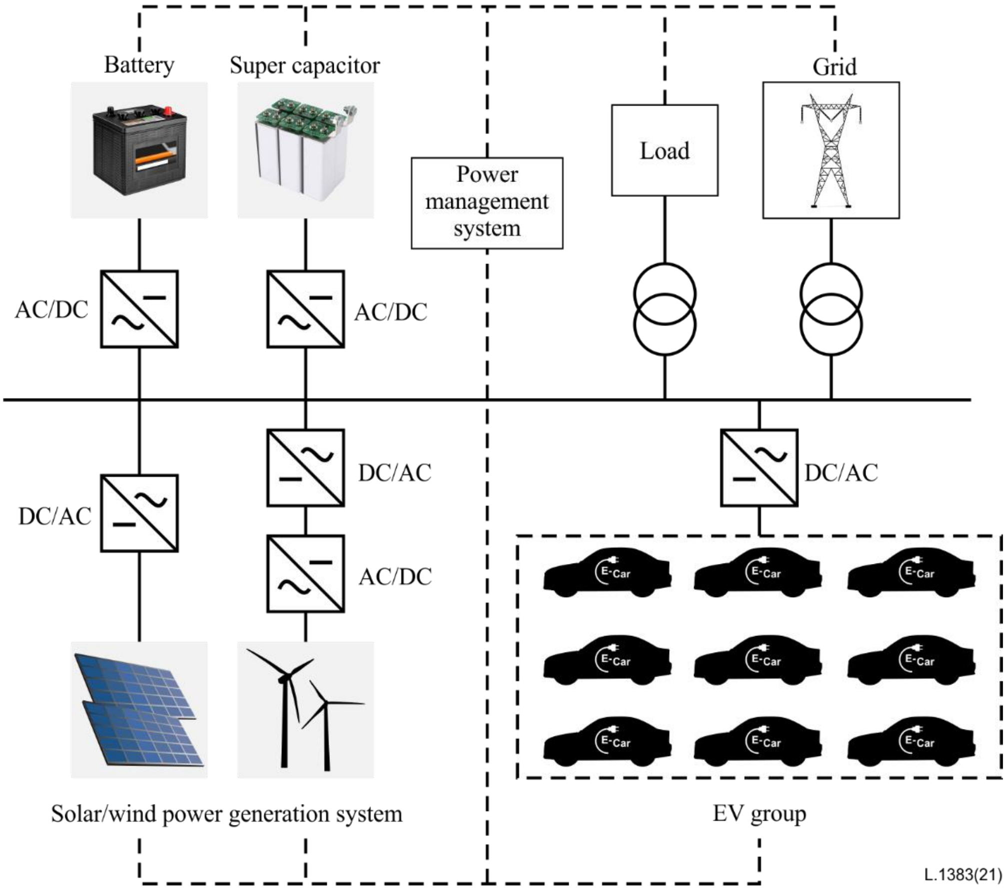

Figure 2 – Smart energy application in residential community (EV – electric vehicle)

6.3 Smart energy applications in industrial parks

In the case of industrial parks, smart energy solutions can help build a comprehensive energy utilizing system, as shown in Figure 3. Combined with traditional energy systems, a smart management system can improve the uptake of photovoltaic energy, wind energy and other clean energies. A smart controlling system is constructed to unify the management of energy and carry out analysis and prediction that would help to improve the utilization rate of regional energy and reduce the overall energy consumption of industrial parks.

NOTE – The buildings numbered 1–11 are factories.

Figure 3 – Distributed energy in the industrial park

Power supply quality and reliability can be improved through the smart energy management system. Data collection and analysis on energy consumption could be achieved by leveraging artificial intelligence and big data technologies. Energy consumption can also be dramatically reduced using smart energy controlling strategies for the data centre as discussed in [ITU-T L.1305] and [b-Qi Shuguang]. Meanwhile, based on the grid price difference in different time periods, the "peak-cutting and valley-filling" method cited from [ITU-T L.1380] can also be applied to reduce the cost of power consumption and improve power supply security in the industrial park.

Due to the massive volume of power consumption in the manufacturing process, it is common that a massive amount of heat would be emitted in parallel. With smart energy applications, heat can be recycled and reused for heating. In addition, by using a smart factory platform, high temperature heat can be recycled and reused as a mechanical power input to support the manufacturing process in factories. As a result, the volume of purchased electricity and CO_2 emission would both be reduced.

6.4 Smart energy applications in electric transportation networks

Smart energy in transportation consists largely of electric vehicles and auxiliary devices such as charging piles. With the application of smart energy, the mode of charging and discharging of electric vehicles will be in a dual-way directional order. There are three types of scenarios in the dual-way mode of charging and discharging:

- In-order charging: When a charging pile is plugged into an electric vehicle, charging work does not begin straight away. The power from a charging pile should be dispatched according to information (such as the residual volume of power or parking time) of users.
- Power demand management: ICT technology, power technology and electricity price data are integrated through smart energy management.

- Electric vehicle charging and discharging in the microgrid: Distributed solar power and energy storage system are commonly found in the parkside microgrid. Through charging and discharging work from an electric vehicle, the above energy source can be connected to the grid by public busbar. Finally, the proportion of clear power provided by a renewable energy source can be increased.

In some cities, there are many public charging stations for electric vehicles with different scales near office buildings. Smart energy application can unify the management of all electric vehicles and relevant infrastructure (charging pile, etc.), make the in-order charging and discharging rules, and facilitate the interconnection with the grid to stabilize the fluctuation of power generating. The basic concept of interconnection between electric vehicles and the power grid can be found in [b-Dmitry Baimel].

6.5 Smart energy applications in municipal areas

Reliable and uninterrupted power supply is at the core of energy use in municipal areas along with energy saving and energy cleanliness. There is a high volume of important, and often confidential, national data transmitted and processed through administration application platforms. There would be detrimental consequences in case of power supply failure. Smart energy application can perform in-time safety prediction based on substantial situational data from the energy utility to minimize the possibility of power supply failure. By connecting with smart sensors of different kinds of power and energy devices, all operation data can be collected and analysed; therefore, any potential safety problem can be identified and relevant solutions will be provided through AI technology. Even in the case of extremely urgent situations, reliability problems can be automatically dealt with, and problem that are diagnosed can be quickly addressed.

When inevitable problems occur in the energy system, a smart energy solution can quickly and effectively isolate the problematic section and resolve the problem.

7 Smart energy applications in the home

With the continuous improvement of living standards, various new types of household appliances have more functions and need a greater power supply, increasing the home energy consumption but providing greater convenience. Smart energy solutions at home can reduce energy consumption, promote energy efficiency, widen the proportion of new energy usage on power generation and create new habits related to power consumption. The purpose of smart energy design at home is making devices smart and energy-saving. Different kinds of sensors can collect energy data, and through ICT techniques such as big data and cloud computing, smart energy management system can control different parts of home powering in real time, such as setting the home lighting system and temperature control system to achieve more comfort and save energy.

7.1 Multi-input multioutput power system at home

With the greater adoption of solid-state electronics, solar photovoltaic power sources, other renewable energy systems and energy storage systems that supply DC power, there is increasing potential for DC-based generation, distribution, storage and utilization equipment. The specific property of this kind of hybrid solution can be illustrated through [ITU-T L.1381] and [ITU-T L.1382].

In some places, many rural houses have a roof photovoltaic module, battery, electric vehicle or even a small wind turbine. Different power generation sources can be integrated by a smart energy system, and it can make the power supply dynamic and optimistic considering the weather, volume of power, load rate, the sort of load and people’s habits. In fact, it increases the proportion of power from renewable energy sources and indirectly reduces the carbon dioxide emission.

This has given rise to an interest in the concept of DC microgrids, which are systems comprised of DC loads and distributed energy resources that can operate independently upon loss of the normal

AC supply. Aside from the resiliency benefits of DC microgrids, DC power distribution can provide efficiency gains since multiple AC/DC conversions are avoided. The benefits of DC microgrids include increased resiliency and safety and improved performance, efficiency and stability, as well as plug-and-play capabilities. Furthermore, DC infrastructure can play a major part in "smart grid" power distribution, along with a decentralized power grid and digitization. The basic structure is shown in Figure 4.

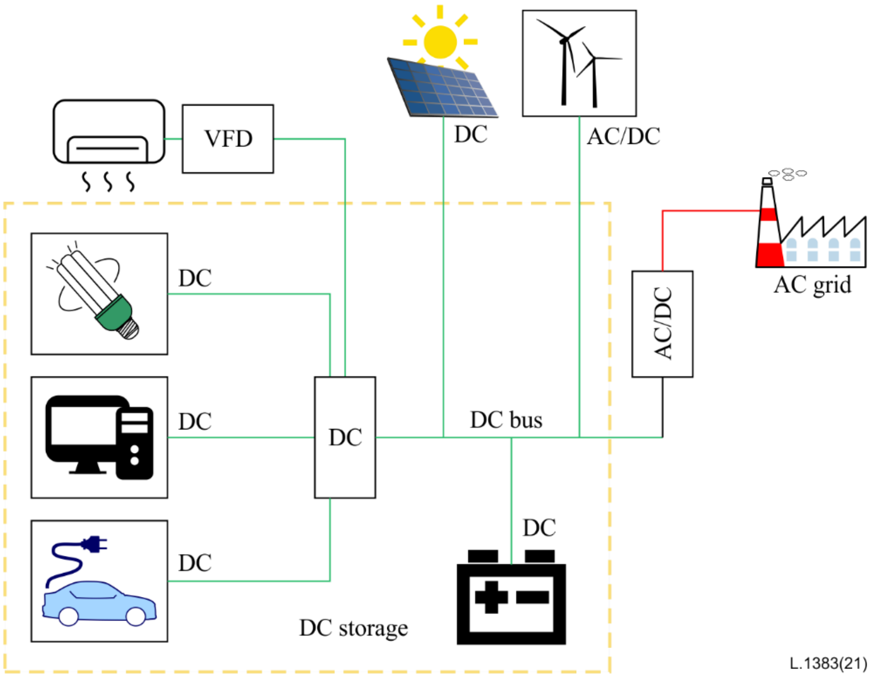

Figure 4 – DC Microgrid in the Home (VFD – variable frequency drive)

Meanwhile, self-generated-and-utilized energy can be powered by photovoltaic and wind power [b-Shujun Liu]. If the amount of residual power is too great to be stored, it is convenient to trade the excess power in the energy market. In another way, smart energy application in the home can effectively train a new type of power utilizing habit. By applying smart energy solutions, a new ecosystem, in which energy efficiency becomes integrated into the core of energy systems at home, could be established.

7.2 Smart energy facility at home

Objects in the home are becoming smarter than before. By applying smart energy solutions, electric and electronic household appliances can be unified in an energy management application. Users can obtain real-time power consumption data, which provides clear information on the power consumption of each device (see Figure 5). Through expert guidance, energy waste and its precise location can be discerned. Thus, new habits of power usage can be promoted, and unnecessary consumption avoided [b-Hongbin Sun].

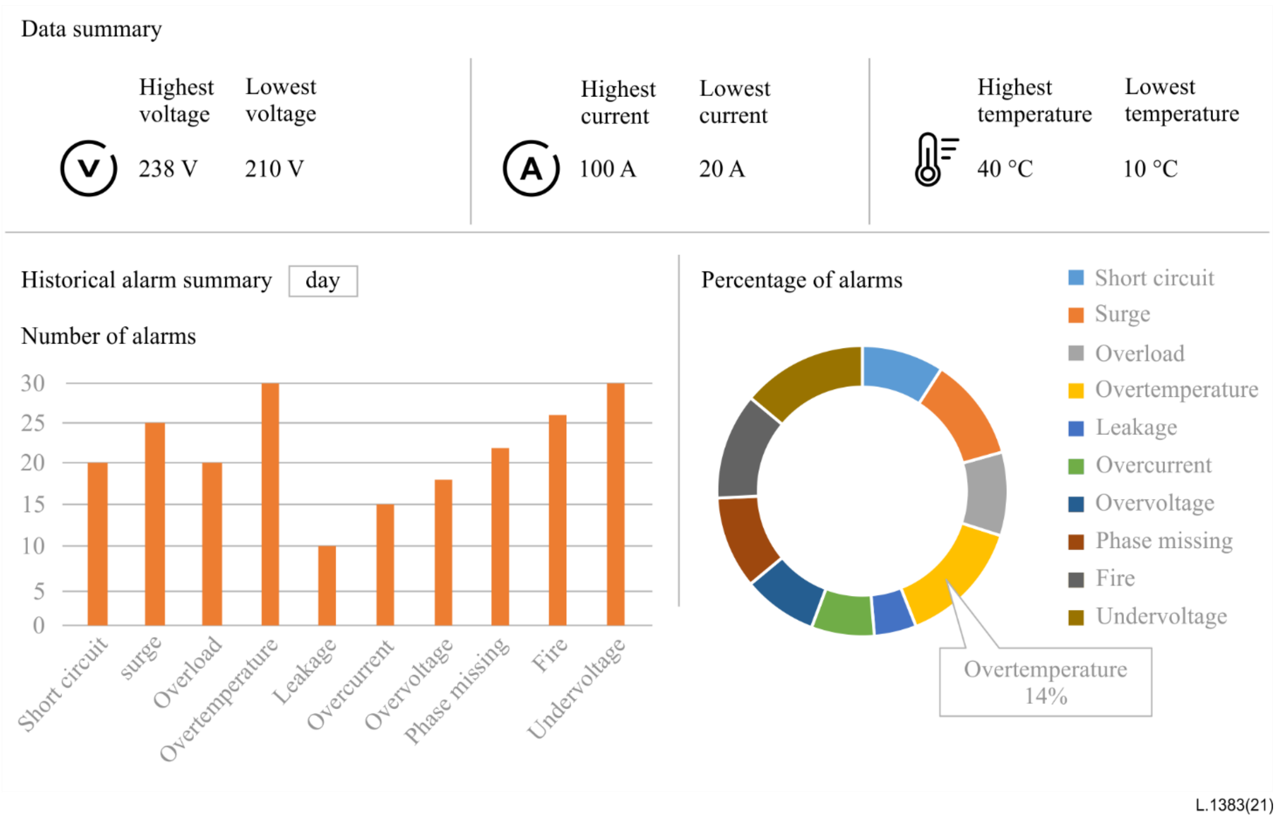

Figure 5 – Energy management application

Aside from their basic function, some current home smart energy solutions also integrate an energy generation and storage function. This additional function helps users to cut energy bills by using solar power during the most expensive peak hours, and selling excess power back to the grid in off-peak hours.

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