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Business Models

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Abstract

In this chapter, we describe the potential impacts of the use-cases on the business activities of the involved market actors as well as the implications from testing the smartDSS functionalities in the context of the Bulgarian and Croatian energy market. It can be concluded that the use of smartDSS assists the daily business of utilities, municipalities, and probably also energy managers and creates new opportunities for their business models in the sense of providing the ground on which new services can be built. Regulatory barriers in the energy markets of Croatia and Bulgaria remain a significant constraint for exploiting the full potential of the energy management system.

Keywords: Business Models, Energy Management system, Regulatory Framework, Demand-Side Management.

9.1 Introduction

The increasing digitization in most aspects of today's society is one of the fundamental changes for the daily lives of all involved individuals. The so-called Internet of things (IoT) allows people and devices to connect with each other at any given time independent from their current location. This opens up a wide array of opportunities of how and when we can access information. These developments are mainly targeted to increase customers' comfort, flexibility, and the potential to save money, as transaction and information costs are reduced notably. However, in some other cases, the

increasing digitalization is becoming also a necessity. This becomes evident in energy sectors that are aiming to reach a high share of renewable energy. Many countries around the world have set ambitious targets to reduce greenhouse gas emissions and subsequently aim to replace fossil energy sources with renewable energies, such as wind and solar power. Besides the reduction in greenhouse gases, the transition of the energy sector is oftentimes linked to broader sustainability goals, such as supporting electric mobility or raising energy efficiency. By extending energy generation from renewable sources, countries can replace existing non-renewable energy sources, such as coal and nuclear power. For instance, Germany strives for a twofold change consisting of nuclear phase-out and a concurrent abolishment of most fossil fuels [1]. Local generation and the inclusion of new actors such as prosumers are key to achieve the energy efficiency targets for the next years.

However, rising shares of volatile renewable energies are also posing many challenges for the energy supply. A successful transformation of the energy sector is often seen as inseparably linked with a smarter grid, as the old paradigm that supply follows demand can no longer hold. Information systems (IS) may constitute a key element of a smarter grid, as they provide the tools for more accurate measurements and predictions. The installation of smart meters in buildings is one of the main parts of required infrastructure. Up to now, individual countries have made very different experience regarding the installation of such smart meters and the development of a smart grid. In order to provide these benefits and meet EU targets, the smart grid must be able to seamlessly integrate various existing and/or new technologies—meters, sensors, data processing systems, etc.—with the physical infrastructure required to generate, transmit, and distribute electric power [2].

Utilities and city authorities have long been using network systems such as SCADA to optimize resources and monitor assets to carry out preventative maintenance. However, the rich data sets generated and stored in these "silo" systems are found in a variety of formats and are not easily accessed by third parties, thus preventing the optimal management, control, and efficiency of many city services (i.e., utilities, security, health, transportation, street lighting, and local government administration). Therefore, new systems are required that are fully functional within a smart grid and allow different market actors to access required data without violating the privacy of connected consumers and prosumers.

9.2 Benefit Framework for the Operation of an Energy Management Platform

9.2.1 Evaluation Framework

As with all information systems and technologies, the benefits of the implementation of an energy management system, such as the proposed smartDSS, need to be determined ex ante. We use a framework consisting of several benefit types for the identification of all potential business uses.

There are a number of existing methodologies for the quantification of benefits connected with the implementation of new technologies, such as decision support systems. For the smartDSS, there are a number of potential operators, which can yield different individual benefits. One common methodology suggests following a path similar to that applied to most other technological innovations [3]. This approach proposes the adjustment and application of well-established methods from the fields of capital budgeting and performance measurement. Mostly this method above addresses the problem of how to achieve overall quantification with the aim of establishing a basis for decisions regarding the initiation or postponement of an investment in a new technology (or, for that matter, decisions in respect of any investment accompanied by cost–benefit consequences that are insufficiently understood).

While some studies indirectly address ex ante benefit evaluation (namely field studies and live tests that require an actual implementation of the new technology), the remainder focus on only one or two of the three main aspects of benefit evaluation: classification frameworks, such as [4] help in identifying potential benefits of new applications without addressing quantification issues. Forecast models, such as the one presented by [5], address the forecast problem of investments, which is, on predicting the extent to which the number of processes and activities and/or resource consumption change, while largely neglecting the financial side. Finally, assessment models, such as [6] focus on the assessment problem, that is, on attaching a monetary value to multiple process improvements, while using "expert estimations" to bypass the forecast problem.

Based on the work from [7], the mentioned results can be adjusted in an ex ante evaluation framework that splits up potential benefits from the implementation of a decision support system into 3 benefit types:

Information: The measurement, collection, and visualization of production and consumption levels. As the smartDSS collects and displays detailed near real-time consumption and production data, it allows to create an overview of the current status of the grid and local areas. These information benefits

do not require modified structures and processes. They might, however, include additional data gathering, which is not economically feasible without a smartDSS.

Optimization: Active balancing of production and consumption levels. As the smartDSS comprises both a centralized (CDSS) and local component (LDSS), it also allows to activate additional capacities, e.g., through demand-side management. This can happen both through immediate action (direct load control) and through long-term based changes in the pricing structure (e.g., the creation of new real-time tariffs). Equivalently, potential optimization benefits can comprise the optimal activation or deactivation of additional production and storage units.

Transformation: Re-engineering of existing business processes and invest-ment decisions. Based on information and analytics functionalities of the smartDSS, decisions about investments into new infrastructure can be made, e.g., new solar panels in areas with high solar power potential or about the enhancement and reinforcement of the grid. Detailed information about consumption and production at all times allows an optimal market behavior and restructuring of the supply chain management.

While these three effects are helpful for identifying and categorizing benefits of the implementation of a decision support system, they offer only limited guidance for selecting and applying concrete instruments for an ex ante benefit quantification of a smartDSS operation. Therefore, these three benefit types can be further split up to help in identifying the related business potential in a case-specific setting and that are linked to specific quantification, i.e., forecast and assessment instruments.

Direct Benefits: Direct benefits of the operation of a smartDSS are under-stood to be effects that are immediately positive results of introducing the technology.

Indirect Benefits: Indirect benefits result from changes in decisions or systems that are enabled by a purposeful distribution and utilization of the data. They are therefore delayed in time and may be realized at different locations than where the data were collected.

As per definition, there exist no direct transformational benefits, as long-term changes within the organization or new investment decisions are only realized indirectly from the utilization of the data. These direct and indirect benefits can be further split up into operational and managerial benefits:

Operational Benefits: Operational benefits are created through improved work processes on a day-to-day basis. These benefits are therefore not based on a restructuring or implementation of new work processes but on a refinement of existing ones.

Managerial Benefits: Managerial benefits denote effects stemming from enhanced management support with integrated, aggregated, energy data which, in most cases, has been further refined and are targeted toward long-term positive results of the business processes. Managerial benefits require a data pool that is integrated and aggregated, and that stores historical data. Managerial benefits are by definition always indirect since they are based on data usage and are not realized in the short run (Figure 9.1).

9.2.2 Assessment of Benefits for Energy Providers

By sub-categorizing information, optimization, and transformation benefits further into direct/indirect and operational/managerial benefits, we derive in total eight benefit types for the operator of a Smart City Energy Management Platform, as visualized in Figure 9.2. As an operator, we thereby assume an energy provider or a utility that manages the delivery of energy to the end consumer.
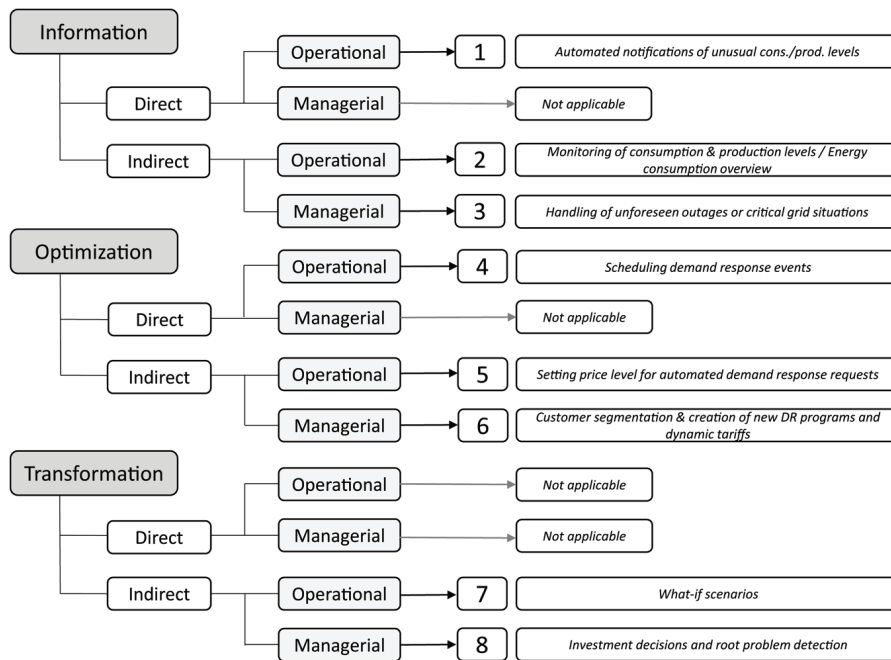
Figure 9.1 Segmentation of eight benefit types connected with the implementation of a Smart City Energy Management Platform.

Type 1—*Automated notifications of unusual consumption and production levels*: This benefit type can be directly generated from displaying information within the smartDSS and setting thresholds for which the system automatically gives a signal when it is reached. Unforeseen fluctuations in the energy production levels of solar and wind power installations can seriously jeopardize grid stability or cause significant costs to the energy provider by the activation of expensive balancing energy. Simultaneously, aggregated consumption levels can change unexpectedly, oftentimes in response to weather conditions as well. Automated notifications thereby help to anticipate critical grid situations. They lay the basis for further actions, e.g., optimization through sending out demand response requests.

Type 2—*Monitoring of consumption and production levels/energy consumption overview*: The smart meter data captures continuous consumption data, which enables the identification of inefficient consumption behaviors, especially for public buildings, since energy consumers here have little incentives to use energy efficiently, as they do not have to pay for the costs. For instance, public buildings may be kept heated on weekends, even though they are not used. The analysis of smart meter data helps to detect those inefficiencies in consumption patterns and significantly reduce energy costs. In contrast to benefit type 1, this benefit type is generated indirectly, through the manual analysis of data.

Type 3—*Handling of unforeseen outages or critical grid situations*: Based on the monitoring of production and consumption data, as well as their graphical display within the energy management system, specific bottlenecks within the grid can be detected. This allows to create strategies of how to handle situations, in which certain components of the smart grid become unavailable, e.g., during the replacement or failure of existing battery storages. Since the handling of unforeseen outages can cause very high costs, in the worst case through the blackout of the whole system, the required strategies can only be created on a managerial basis, through the careful evaluation of all existing data.

Type 4—*Scheduling demand response requests*: An active demand-side management can generally reduce the need to call expensive backup capacity in times of peak demand. For instance, some older power plants are no longer used on regular basis, but are infrequently activated to cover the peak demand on some days. This operation is not efficient both economically and environmentally. An active demand-side management as alternative to the activation of costly backup capacity can result in considerable savings for energy providers [8].

Type 5—*Setting price levels for automated demand response requests*: Based on the direct benefits from scheduling demand response events, the results from previous requests and customers' reactions can be analyzed for the adjustment of incentive schemes that are required for the participation of consumers.

Type 6—*Customer segmentation and creation of new demand response programs and dynamic tariffs*: Based on the benefit types 4 and 5, conclusions on a managerial basis can be taken regarding the segmentation and clustering of certain types of consumers. As some groups of consumers might exhibit a high price elasticity while others do not, the implementation of specifically tailored dynamic tariff schemes can help to ensure customer retention, while at the same time influencing aggregated demand in a beneficial way for the energy provider.

Type 7—*What-if scenarios*: A powerful functionality within the energy management system is a planning tool that allows to calculate the effects of adjustments or new installations in the grid. For instance, large amounts of additional PV panels, wind turbines, or battery storages might cause large effects on a certain part of the grid or even to the whole system. The tool allows estimating these effects prior to the installation. The connected benefits therefore arise indirectly through the transformation of existing business processes.

Type 8—*Investment decisions and root problem detection*: Lastly, the energy management platform can yield benefits that are only realized in the long run on an indirect and managerial basis from restructuring whole business processes. For instance, an active demand-side management reduces dependencies on suppliers of backup capacities. This can prove beneficial for the negotiation of future long-term contracts or the portfolio management at wholesale markets. Additionally, benefits arise from the detection of root problems in the infrastructure or existing business processes.

9.3 Business Benefits for Related Use Cases

This section contains a brief description of the use cases that are related to the CDSS on an operational level, as well as an outline of the associated benefits in the energy market.

9.3.1 Creation of City Energy View

A key component of smart grids and other energy supply systems is to have sufficient information about the current status of the system through a variety of

measurement points. These embedded processing and digital communications enable the energy grid to be:

- observable (able to measure the states of all grid elements)
- controllable (able to affect the state of any grid element)
- automated (able to adapt and self-heal)
- fully integrated (fully interoperable with existing systems and have the capacity to incorporate a diversity of energy sources).

The ability to display all relevant information from the supply chain to the end consumers, most importantly supply and demand levels, is one of the central and basic components of the smartDSS. It will include data for historical, current, and forecasts for future time horizons:

- Visualization of the near real-time energy status of the city.
- Visualization of the forecast (24/48/72 hours) for the energy status of the city.
- Visualization of the history (e.g., last day/week/month/year) for the energy status of the city.

To capture and display, all relevant data can create already a variety of different benefits, such as the detection of inefficient consumption patterns. The smart meter data capture continuous consumption behavior in the buildings in the pilot cities with installed equipment. As was found out during the first period after the installation of smart meters, one school building in Rijeka was fully heated over weekends when building was vacant. It turned out that the housekeeper responsible for the building was leaving the heating on over the weekend. The analysis of smart meter data helps to detect those inefficiencies in consumption patterns and significantly reduce heating costs.

The city energy view has the option to display all relevant consumption and production data as basis for the decision making process. The identification of trends in the consumption and production data (seasonalities, working day/weekend, hours of the day) allows the effective management of the supply and demand side. For instance, the detection of certain trends can help to optimize the purchases of needed quantities of energy supply, e.g., at the wholesale market. This is because it is usually cheaper for an energy retailer to make purchases of needed quantities early in advance. Short-term energy supply purchases are mostly connected with higher risks, e.g., higher price volatility at the intraday market, and necessity to activate balancing energy. Alternatively, peaks in consumption can be met through the creation of new dynamic tariffs or specific demand response events. For this, it is needed to

clearly detect when exactly peaks in demand occur and how strong they are. Equivalently, the connection of certain weather conditions to production and consumption levels is enabling the utility to make better forecasts, which in turn allows an effective supply and demand-side management.

Connected benefits to the creation of a city energy overview are therefore:

- Tool for quickly capturing an overview of data and energy flows.
- Detection of inefficiencies or unusual production/consumption levels within the regional area.
- Basis for decisions about certain actions (e.g., sending out demand response requests, shutting off certain energy production units).
- Identification of bottlenecks in the system or areas for grid enhancement.
- Identification of trends in the consumption and production data (seasonalities, working day/weekend, hours of the day).
- Decision basis for portfolio optimization at wholesale market, i.e., day-ahead or intraday markets.
- Decision basis for the creation of new demand-side management measures, e.g., creation of dynamic tariffs or demand response events.

9.3.1.1 Testing and validation in the pilot of Plovdiv

The energy view option is the first step: The utility company can take to an effective energy management. With a view to the greater digitalization of the energy market, close to real-time energy view is a pre-condition for building the future complex processes and relations.

Through the monitoring tool, the utility can obtain the information needed for the decision making process which aims at energy efficiency and reduction in costs for investment and maintenance and repairmen. All the measures and decisions which are taken are on the basis of the information for the consumption (resp. production)—historical, current, and future forecast. After decision and implementation of action, the energy view option again gives feedback if the action taken achieves the desired results or not.

Thus, as stated, the energy view option is the basis on which the future actions are planned (Chart 9.1).

The CDSS provided to EVN TP and EVN EP (the heat and distribution grid companies), the means for monitoring the status of the consumption of heat (electricity) energy of a building, region, or the whole city, and at the same time to track also the energy production. The software presents a unique opportunity for grid operators (heat or electricity) to have an overview on the energy flows—production and consumption in close to real time.
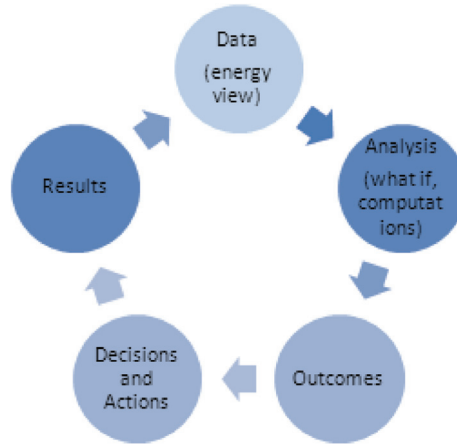
Chart 9.1 Data and decision process.

Thus, through the use of the CDSS, EVN TP has overcome a technical limitation in the use of a more user-orientated software which can be used both from technical and customer relations departments (Chart 9.2).
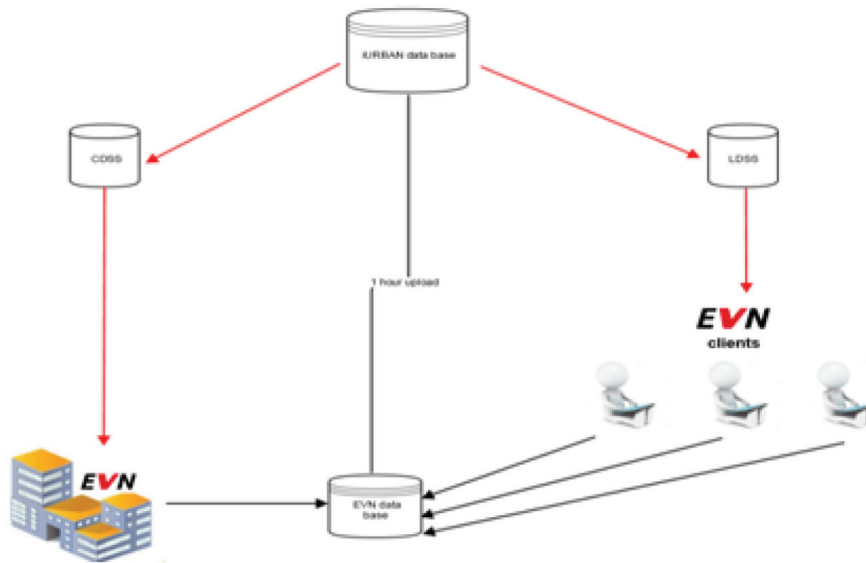
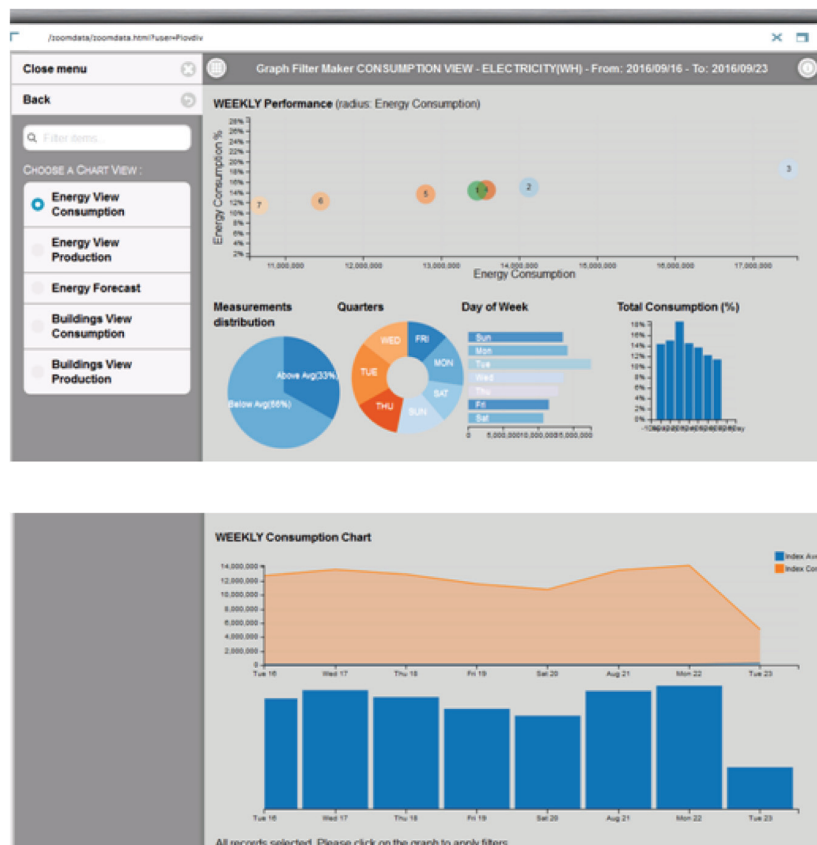**Chart 9.2** Use of the smartDSS in the pilot of Plovdiv.

Figure 9.2 Plovdiv city energy weekly view.

The city energy view option is helpful in the energy planning and balancing. Thus, it is also supported by a forecast function. In this way, the actual use of the CDSS could help the utility companies to achieve higher reliability of the grid infrastructure and at the same time lower costs and achieve energy efficiency. If the software encompasses the whole city consumption, then the tool will be very helpful in terms of the medium- and long-term planning of investment in new capacities, facilities, and energy infrastructure as a whole. In the case of the city of Plovdiv which is period of re-industrialization and opening of new factories and production capacities, a good overview of the energy consumption and production equips the utility with a mechanism or monitoring and analyzing of the needs of a region or the whole city.

Through the energy consumption view option, we have monitored the consumption patterns in the participating buildings. We identified when the peak times for energy consumption are. For electricity consumption, these are the morning hours between 6:30 am and 8:00 am, and in the evening 18:00–21:00 pm. For heating, the peak hours of consumption are the evening 17:00–21:00 pm.

The historical consumption option provides a handy tool of tracking the deviations in consumption pattern which can be due to not just energy savings but some technical problems. For instance, Figure 9.3 gives an overview of the hot water consumption in Plovdiv and the days with the peaks. This provides an indication for the utility to have a closer observation and check for the reasons for the increased consumption.

On the basis of the historical and current consumption and pattern tracking, we could identify possible additional services which we can offer to the customers. When there is a potential for savings, we could offer or even develop tailor-based solutions for the buildings to optimize their energy consumption and reach higher level of energy efficiency. Furthermore, the building comparing option helps to identify whether the implemented energy efficient measures in a comparable similar building gives results compared to a building with no such measures taken (Figure 9.4).

The energy forecast option gives us an idea what will be the demand for the following period. Thus, this has allowed us as power plant operator to align the production based on the estimated consumption. However, the results which are visible through the software are only representative. Still the significant number of the DH customers in Plovdiv use metering devices which do not
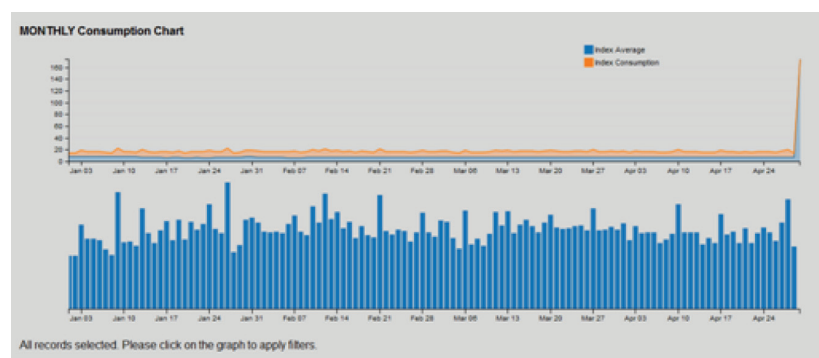
Figure 9.3   Hot water consumption in the city of Plovdiv (01.01.2016–30.04.2016, covering the heating season).
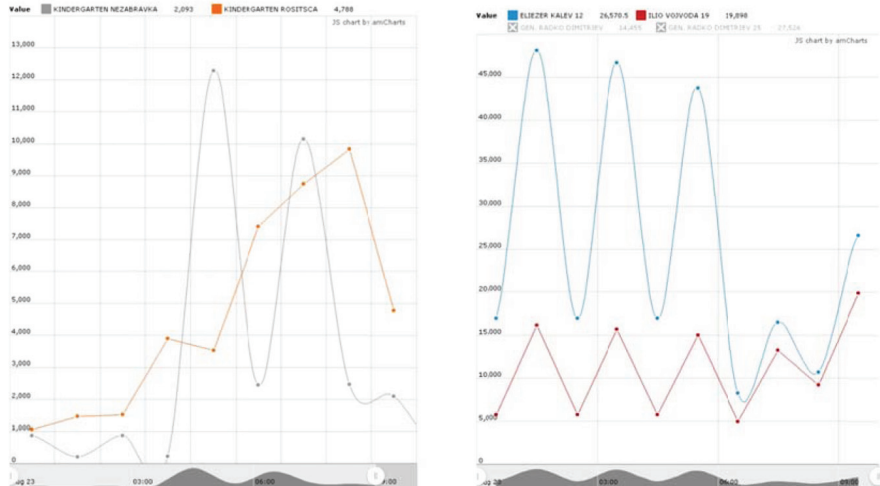
Figure 9.4 Electricity use over 1 day (23 August 2016)—comparison between two kindergartens (*left*) and two buildings with relatively similar characteristics (*right*).

allow hourly reading or their internal heating installation is vertical without individual metering devices.

9.3.1.2 Testing and validation in the pilot of Rijeka

The CDSS provided for municipal and utility users in Rijeka had the goal to provide users with consumption details for buildings included in project. Also, both types of users could make parallel testing and validation of data shown in the system with the data shown in other data systems (installed by manufacturer of metering equipment or other proprietary databases).

Municipal users had the opportunity to monitor consumptions of several energy sources used in each building and to help them decide what measures might be taken in the future to try and reduce (or control) the consumptions. From their experience with the CDSS, the municipality deems the following:

- Application is user-friendly
- It provides service management of energy consumption
- Users must have a basic technical knowledge to use this application
- It provides quick response with unusual consumption
- It reduces reaction time for detect failures and losses on installations or devices. That way, we can reduce negative impact on the environment and reduce the financial losses
- The user can control the consumption indicated in the invoice supplier.

The CDSS has enabled us to respond more quickly to energy issues. It enables to identify specific situations where there are discrepancies in consumption that were not consistent with historical data or operations. Being able to identify these anomalies, the CDSS allows to dig deeper to identify issues that could be corrected. Now, the municipality can respond quickly and avoid costs in the future as well as to control operations beyond its normal cycle.

For example, in one elementary school, we detected increased heat consumption over the weekend. In a short time, we determined the cause. We separated the heating system that is used by the school facilities (5 days a week) and the other parts of the building that are consuming heating energy the whole week. We could not say with certainty the total amount of savings achieved by this action as during the same period the school was reconstructed (new facade with 16 cm of thermal insulation).

Overall, the implementation experience of CDSS has been valuable. Increased visibility of energy issues has aided in goal setting and overall promotion of energy management efforts. CDSS helps us to do proactive energy management and building the City's energy program and metrics around it. Utility users had the same possibilities as municipal users but with the addition of some extra options that have been tested and reported through demand response program.

Energy view that has been tested here has shown great benefit to utility company because utility users could monitor consumptions and at the same time monitor the influence of user-driven actions on the gas grid that utility manages. As described in demand response paragraph, utility had tested part of interface that is used for communication with private users by sending notifications about how users could act in order to influence gas network and overall gas consumption.

Based on these data about user behavior and participation in given notifications and actions, utility would get feedback how to balance gas network and daily consumption curve. This type of system enables direct communication with customers and at the same time gives direct real-time readings that are needed in this type of energy business due to obligation of utility company to buy and reserve amounts of gas on everyday basis. This system, being quick and responsive, and paired with, e.g., SCADA system with gas prediction and optimization modules, gives great opportunities to utility companies to optimize their gas networks and costs regarding gas transport and overall management. If this software would be used to cover all aspects of energy consumption and all utilities, it would be excellent for energy planning and balancing actions, and therefore widely mentioned energy efficiency.

9.3.2 What-if Scenarios

The "what-if" analysis can be a powerful tool for the energy provider, DSO, TSO, or other market actors, such as municipalities, as it gives them the possibility to evaluate the impact of certain actions on the energy system.

Distribution grid operators, for instance, are responsible for the maintenance, expansion, and reinforcement of the low-voltage grid and at the forefront for integrating distributed renewable energy sources into the grid. While the traditional system required the delivery of electricity from large power plants to densely populated urban areas, distribution grids now have to cope with the feeding in of large quantities of renewable energies and thus are required to support bidirectional energy flows. Demand response, along with other measures, can serve as alternative to extensive grid capacity enhancement, as it is able to ease temporal congestion of the grid. Large amounts of small decentralized production units, such as solar panels and windmills, can oftentimes be a big challenge for securing the stability of the grid, as their production is intermittent and difficult to predict. Therefore, grid operators can use the "what-if" functionality of the smartDSS to simulate certain events. For instance, the feed in of large quantities of solar and wind power on a sunny and windy day or an outage of an important power plant.

Equivalently, "what-if" scenarios can be used to detect or evaluate the necessity and benefits of investments in new infrastructure. This could be the construction of a new array of solar panels with a large capacity in a remote area of the grid system. Simulations of how the influx of large quantities of renewable energies might influence the grid system can identify the need for additional investments in infrastructure and grid enhancement.

Energy retailers can optimize their portfolio of buying energy at the spot market if they can evaluate the impact of certain weather conditions on the overall levels of energy production and consumption. An execution of a "what-if" analysis for the future (e.g., 24, 48, 72 h) for the energy status of the city allows making precise decisions about energy transactions at the day-ahead or intraday market. For instance, when it is forecasted that the next day is going to be cloudy and windy, this results in certain production levels from solar and wind power and consequently in certain requirements for short-term portfolio optimization.

In general, the "what-if" analysis can create the following benefits:

- Short-term portfolio optimization at day-ahead or intraday markets for energy retailers in response to expected weather conditions

- Simulation of certain levels of solar and wind power production and their effects on the energy system
- Better possibilities to maintain grid stability for grid operators by the accurate activation or avoidance of balancing energy
- Possibility to identify most suitable production units for shut-off in case of overproduction of renewable energies
- Investment decisions in new capacities or grid enhancement when bottlenecks are detected
- Evaluation of effects of the installation of additional power plants, such as windmills or solar panels.

9.3.3 Auditing/Billing

The functionality of auditing and billing allows the energy provider to manage and implement new tariff schemes efficiently. This will be especially valuable as the number of available tariffs is expected to increase due to the liberalization of the market and the possibility to implement dynamic tariffs.

With the implementation of such tariffs, the energy sector can balance out demand levels and benefits from a reduced infrastructure needed to generate and distribute power at peak times. It can also cut energy procurement costs through lower peak prices and reduce vulnerability to service failures such as blackouts.

Responsive demand driven by dynamic pricing can also reduce greenhouse gases and local pollutants. Enhanced price signals can cause customers to shift demand away from peak times, avoiding emission-intensive generators used to serve system peak in some regions. Customers may also cut demand entirely due to enhanced price signals and better consumption information from smart metering.

- Fixed—in which the consumer is charged the same amount for the electricity used no matter what time of day it is used. A fixed rate energy tariff is typically set for 1–2 years. During that time the consumers pays the same amount for their electricity regardless of any price changes in the market.
- Time of use (TOU)—in which electricity prices are set for a specific time period in advance, typically not changing more often than twice a year. Prices paid for energy consumed during these periods are pre-established and known to consumers in advance, allowing them to vary their usage in response to such prices and manage their energy costs by shifting usage to a lower cost period or reducing their consumption overall.

- Critical peak pricing (CPP)—High price periods may or may not occur depending in the status of current consumption and production levels. Price signals are provided to the user on an advanced or forward basis, reflecting the utility's cost of generating and/or purchasing electricity at the wholesale level.
- Real-time pricing (RTP)—Prices may change on an hourly basis or even in short time periods. Price signals reflect the current status of the grid or wholesale market prices as well as the general level of production and consumption.

Customers can benefit from a dynamic tariff if their overall energy bills decrease. As the energy provider does not need to charge risk premiums on top of a single tariff, the overall price levels can decrease from the adoption of dynamic tariffs. In general, peak demand is one of the most expensive cost parts for the energy provider (e.g., keeping backup generators available). Therefore, with the ability to influence the demand side, the energy provider might be able to reduce overall costs, allowing it to forward parts of the savings to customers as reduced tariffs.

The functionality to manage tariffs at the smartDSS can have further benefits for the billing process for customers, as it possible to accurately measure when and where energy has been consumed. This can help to create detailed bills on an automated basis. Being able to take exact measurements of consumption without having to read out meters manually any time it is necessary, can reduce costs of these process significantly. It is easier for the energy supplier to detect which customers are consuming energy but not paying their bills. Complaints and law suits from customers might be settled easier and faster as it is possible to proof exact amounts of consumption on an automated basis.

9.3.4 Technical and Non-technical Losses

Generally, in electricity supply to final consumers, losses refer to the amounts of electricity injected into the transmission and distribution grids that are not paid for by users. Total losses have two components: technical and non-technical. Technical losses occur naturally and consist mainly of power dissipation in electricity system components such as transmission and distribution lines, transformers, and measurement systems. Non-technical losses are caused by actions external to the power system and consist primarily of electricity theft, non-payment by customers, and errors in accounting and record-keeping. These three categories of losses are respectively sometimes referred to as commercial, non-payment, and administrative losses.

From a regulatory or governmental perspective, it is beneficial to reduce the total amount of technical and non-technical losses as much as possible, as its reduction means that less energy has to be produced overall. This is generally connected with lower costs in the energy sector, which has benefits to the society overall.

Especially, non-technical losses represent also an avoidable financial loss for the utility. As an effect, customers being billed for accurately measured consumption and regularly paying their bills are subsidizing those users who do not pay for electricity consumption. A classic case is a theft of electricity through an illegal connection to the grid or manipulation of a consumption meter. But examples also include unmetered consumption by utility customers who are not accurately metered for a variety of reasons.

Detect inefficiencies in power distribution

Having a variety of different measurement points between the point of generation of energy, its transmission and distribution, and the final area of consumption helps to detect where any losses on its way occur. Especially for electricity, the supply chain typically involves the transfer of electricity through the high-voltage grid, medium-voltage grid, and the low-voltage grid. At the same time, several market actors are involved in the supply chain, including producers, TSOs, DSOs, and the energy retailer, which typically have incomplete information about the status in the other parts of the delivery chain.

Having measurement points at these different parts of the supply chain can help to detect at which part inefficiencies or defaults occur. The visualization on a graphical map makes it possible to track exact locations. The information taken from the smartDSS allows restructuring process or enables decisions about investments in the corresponding infrastructure.

Identification of energy theft: Energy theft is a serious problem in many energy markets worldwide and can occur in many different forms, the most prominent contain the following:

1. Direct hooking from line, where the consumer taps into a power line from a point ahead of the energy meter. This energy consumption is unmeasured and procured with or without switches.
2. Bypassing the energy meter, where the input terminal and output terminal of the energy meter is short-circuited, preventing the energy from registration in the energy meter.
3. Injecting foreign element into the energy meter, where meters are manipulated via a remote by installing a circuit inside the meter so that the meter

can be slowed down at any time. This kind of modification can evade external inspection attempts because the meter is always correct unless the remote is turned on.

4. Physical obstruction or other form of manipulation of the smart meter. Often a foreign material is placed inside the meter to obstruct the free movement of the disk with traditional meters. A slower rotating disk signals less energy consumption.

With the smartDSS, significant deviations between the smart meter data at building level and the sum of smart meters data at apartment level are detected. Alternatively, the smartDSS can also filter for regional or district level. This makes it much easier to identify any form of energy theft, as the supplier does not have to rely purely on the energy meter. In addition, with a rollout of smart meters, it is not directly possible to physically alter or manipulate the work process within the meter.

Identify non-payment by customers: The identification of non-payment by customers can especially valuable for the case of heating in big residential buildings with multiple parties that rely on heat-cost allocators. Due to the characteristics of physical distribution of heat through the residential buildings, it is not possible to completely exclude some customers from heating even though they choose not to pay their bills. If some customers decide to opt-out of their tariffs, the fixed part of the costs of heating supply gets reallocated to the remaining customers in the building, which in turn have increasing incentives to opt-out. Therefore, customers that do not share their part of the costs are getting subsized by the paying customers, as apartments still receive heating from the flow through the building. As a result, in energy suppliers, such as EVN in Plovdiv, face large numbers of law suits from customers who feel that they are unjustly treated, mostly those who have to take the additional costs.

Being able to take exact measurements of consumption without having to read out meters manually any time it is necessary, can reduce costs of these process significantly. It is easier for the energy supplier to detect which customers are consuming energy but not paying their bills. Complaints and law suits from customers might be settled easier and faster as it is possible to proof exact amounts of consumption on an automated basis.

Avoid errors in accounting: Similar as to the detection of energy theft, the smartDSS here has the functionality to detect significant deviations between the smart meter data at building level and the sum of smart meters data at apartment level. Therefore, the energy utility can double-check any errors

that might have occurred during the metering, accounting, or billing processes. In addition, processes of re-billing, e.g., after a customer complaint, can be done much easier and faster, which is connected to lower costs of the billing system.

9.3.4.1 Testing and validation in the pilot of Plovdiv

The so-called technical losses in the heat distribution grid refer to the costs from transportation of the energy from the point of production to the point of consumption in Bulgaria. As with all other goods, for the good "heat energy," there are also costs for transportation of the good between the producer and the consumer. These costs in the transportation of the energy are not paid as energy by the customers as they cannot be avoided and are associated with the transportation of heat energy to the buildings. They are taken into consideration by the Regulator in Bulgaria when determining the end price for heat energy for the DH companies. Thus, they are not directly covered by the end customers but are part of the end—price for the heat energy.

Estimated production processing costs and realization of thermal energy for heating, cooling, and domestic hot water/hot water/for Plovdiv over the years will be as follows:

In contrast, what is denoted in the CDSS software as technical losses is actually the loss of energy (for heating and hot water) in the heating substation and the internal installations of the buildings as it measures the difference between the energy supplied to the building and the energy consumed in the individual apartments. However, this is not necessary a loss as such, as the internal installation also releases heat for which energy is needed and it cannot be considered a loss as the energy is used to warm the building same as with the radiators in the individual apartments.

In accordance with the Energy Act in Bulgaria, the internal installation for heating and for domestic hot water in a multi-dwelling building is considered also part of the "common parts" of the building, and hence, the maintenance and management of the common parts rests with all the owners in the buildings

Table 9.1 Estimated production processing costs and realization of thermal energy

Activity	Measure	2014	2015	2016	2017	2018	2019
Production	MWh	310,833	353,257	355,804	357,389	358,454	361,476
Technology expenses	MWh	118,948	132,057	128,737	126,675	123,756	121,474
Technology expenses	%	38.27	37.38	36.18	35.44	34.52	33.60
Realization	MWh	191,885	221,200	227,067	230,714	234,699	240,002

in proportion to their share percentage of the common parts. In the same vein, the costs for the energy used in the internal heating installation are shared among the apartments using the service in proportion to the heated volume of their apartments. The distribution of the heat released by the internal building installation is made following a complex methodology approved in Ordinance [1]16-334/2007 for share distribution of heat energy in multi-dwelling buildings ("the methodology"). The methodology incorporates a complex mechanism which takes into account the type and the thermo-physical characteristics of the building and the heating system.

However, the CDSS took a more generalized approach which can be applied in a number of different situations and does not follow strictly the approach set out in the methodology in Bulgaria. Thus, the approach of the CDSS can be applied to various buildings in various countries and the logic stays the same—difference between supplied energy to the whole building and sum of the consumed energy in the individual apartments (Figure 9.5).

The function in the CDSS gives a basis for review of the mode of consumption for different buildings and provides a basis for analysis why the "technical losses" in certain buildings are lower than in others and what measures are taken to diminish them. This analysis is a basis for the utility to make a plan what kind of services for maintenance and improvement can be offered to a building with high values of technical losses. Thus, the CDSS offers the possibility for creating building profile and possible list of consultancy or additional services which can be offered to customers in this building.
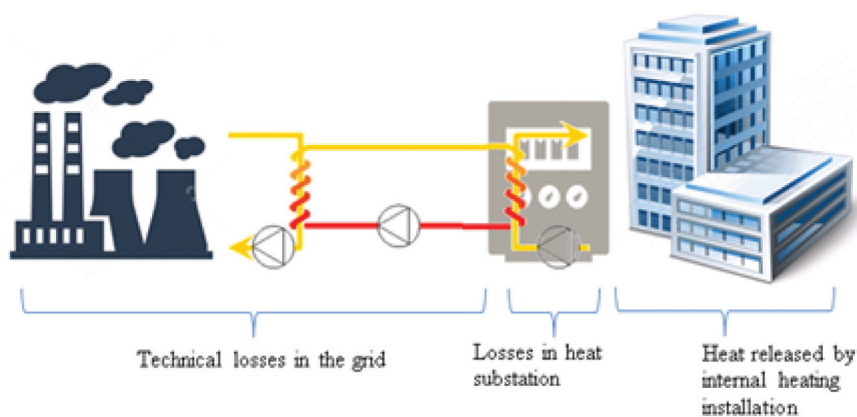
Figure 9.5   District heating grid scheme.

Furthermore, the function in the CDSS is also a helpful tool to detect some deviations in the technical losses and investigate the reasons for. They can be due to leakages, improper use of energy, or some technical problem. At least in Bulgaria, the maintenance of the internal installation is a responsibility of the inhabitants of the building, but the information for the technical losses in the CDSS represents an overview of the building and gives signals for possible improper use. Overall, reduction in the technical losses leads to reduction in the consumption of energy and less GHG emissions.

9.3.5 Demand Response

9.3.5.1 The model

Demand response relates only to electricity energy. Through demand response, final consumers (households or businesses) provide flexibility to the electricity system by voluntarily changing their usual electricity consumption in reaction to price signals or to specific requests, while at the same time benefiting from doing so.[1]

In order to provide the necessary IT tools to make this happen, the CDSS provides the following functionalities:

- User can create/modify/delete DR programs (every DR program is associated with a peak of energy consumption);
- User can get information about peaks of energy consumption;
- User can manually create a peak of energy consumption;
- User can create/modify/delete notifications related to associated peak of energy consumption;
- User can get information about peak of energy consumption;
- User can get information about the status result about every notification associated to a chosen peak of energy consumption.

Testing and validation in the pilot of Plovdiv

The demand response business case was not implemented in the city of Plovdiv. There are two major barriers before the implementation of demand response in Bulgaria at the time the project was realized:

- Regulated prices by law for customers connected to low-voltage network and no justification of expenses for rewards for shift in the consumption.

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[1]Eurelectric, "Everything You Always Wanted to Know about Demand Response," Dépôt legal D/2015/12.105/11, available at <http://www.eurelectric.org/media/176935/demand-response-brochure-11-05-final-lr-2015-2501-0002-01-e.pdf>, p. 3 ("Eurelectric Demand Response Report").

• No economic benefit for customers to switch to the free market due to regulation of the prices for purchasing electricity and margin of the utility.

9.3.5.2 Regulatory environment

As it has been mentioned on several occasions in previous documents, demand response has not been tested in Plovdiv due to some legal impediments which prevented implementation.

The full liberalization of the electricity market in Bulgaria was launched as of July 1, 2007 and it is a step-by-step process which started with liberalization of the wholesale market and gradually continues with the retail one.

Customers connected to the low-voltage (residential and small business customers, i.e., the participants in iURBAN project) are still on the regulated market where the prices are regulated and fixed by the Energy and Water Regulation Commission of the Republic of Bulgaria ("EWRC").[2] The prices determined by the Regulator are not a ceiling or a framework within which the prices should be. On the contrary, the prices approved by the EWRC are fixed and binding on the DSO and the electricity supplier and represents the price which is billed to the end customer.[3] The EWRC stipulates the grid connection and distribution fees, the price for electricity for the end customer (BGN per kWh), and other ancillary services for a certain regulatory price period (which is usually a year and starts on 1st of July and continues up until 30th June in the following year).[4] All customers participating in the project are supplied with electricity on regulated prices by the company EVN Bulgaria Elektrosnabdiavane EAD.

Furthermore, it is essential for demand response to provide a reward to induce the shift in the consumption. The current situation of the regulation in Bulgaria does not allow expenses for rewards for shift in the consumption to be justified under the regulated market prices. From accounting and tax perspective, the company would make an expense and next to it there is no profit or benefit because the EVN Bulgaria Elektrosnabdiavane EAD buys electricity on flat rate and sells it to customers on fixed price. Such actions on the regulated market could certainly raise concerns and check by the authorities.

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[2]See Article 21 and 30 (1) of the Energy Act.

[3]See Ordinance No. 1 of 18.03.2013 on the Regulation of Prices for Electricity issued by the Chairman of the State Energy and Water Regulation Commission ("Ordinance on the Regulation of the Prices for Electricity").

[4]See Article 30 (1) of the Energy Act.

9.3.5.3 No real economic benefit

Customers connected to the low-voltage can opt out and choose a supplier of electricity energy and negotiate the price for electricity with it (important note is that the grid service fees are still regulated). However, customers do not have economic incentives to go on the free market, as currently the price determined by EWRC for household customers is significantly lower than what is offered at the liberalized market due to the cross-subsidy of the prices between business and household on the regulated market. EWRC artificially keeps the prices of the electricity for the household customers low at the expense of the prices for the business customers. Thus, there is no real price competition on the market and the household customers (mainly the participants in iURBAN) have no economic benefit to switch to the free market where the supplier can offer more flexible price options and include demand response as well.

To illustrate the situation, the average price for electricity at the regulated market currently is 106 BGN/MWh or 69,50 BGN without the public obligations fee. The price for electricity at the liberalized market is at the average—76 BGN/MWh. The difference of ab. 6, 5 BGN/MWh is obvious and enough deterrent for residential customers to switch to a new supplier.

Testing and validation in the pilot of Rijeka

Demand response program in Rijeka has been tested and implemented with 8 private users. Selected customers use natural gas as a primary heating energy source. The largest gas consumptions occur in the morning (period before people go to work) and in the afternoon (when people are back from work).

Misbalance in consumptions during day is not good for the distribution network, so the goal of DR actions was to influence consumption peaks in gas optimization. Users are motivated to set their thermostats in accordance with the requirements of the DR action in order to reduce the consumptions during the periods of increased consumptions. Demands are appointed by the utility in relation to the consumption overshoot.

At first, enControl needed to be installed. It is a system for home management and control of energy consumption. Through this system, it is possible to operate the home heating system in such way that the temperature of each radiator (thermo-head) and room thermostat can be set separately to achieve most of level comfort for users, while at the same time, users can try to be most energy efficient (lower temperature set points for rooms that are not that frequently used, etc.). The control is provided both through mobile application

(smartphones) and online via cloud service application where each user can log in with assigned username and password.

DR actions have been created a few days before a certain optimization needed to take place and were sent to users in the form of a notification through the Web application. These notifications could then be forwarded to users via any of pre-set ways—via e-mail, SMS, or mobile application (according to the user's selection). The tasks users needed to do in order to fulfill the request consisted of some form of action regarding the main thermostat. Users were instructed the temperature that needed to be set and the time period for which the setting needed to be active (e.g., set your thermostat to 21degC or below, time period: 7 AM–9 AM). If the user would successfully complete the request, he would be notified about successful participation in DR action and would be awarded a coin. Additional coin was assigned to users who fulfilled at least five DR actions during each month of the program. Users who have met all the required DR actions would be awarded additional five coins.

Table 9.2 gives an overview of all DR actions and results for each user. Every DR action shown in the table has several additional pieces of information like the time when notification was sent (scheduled time) and the time when the action took place (action time). Furthermore, it shows the required thermostat temperature during the DR action and outside temperature during this period. In part of the table which gives an overview of the performance for each action by individual user, notification delivery report (first column) is shown. The second column shows whether the user has successfully performed a given task. The aim of each particular DR action is given at the bottom of the table, as well as additional remarks related to the action.

During the demand response program, 19 DR actions took place. The first two were unsuccessful because of notification sending and receiving issues, but the following 17 DR actions were conducted successfully. Altogether, 132 demands were sent by utility and received by users which resulted in 96 demands that have been completed, in total 72.7% positive responses.

It is important to note that participants of DR programs can be described as younger and middle-aged users, familiar with everyday use of computers and other IT devices, so general usage of Web (and mobile) application did not represent a problem for them. Despite all mentioned, the large level of engagement needed for DR actions followed by high rate of sent DR notifications finally did represent a problem for almost all users and had become too intense for them.

Table 9.2 Executed demand response events number 15 to 19

Installations	DR15	DR16	DR17	DR18	DR19
	20	20	19	18	17
Below Avg. Temp. during DR	14,11	12,96	12,29	11,9	15,42
Scheduled time (UTC)	31.03.2016 10:00	01.04.2016 12:00	05.04.2016 09:00	08.04.2016 09:00	11.04.2016 11:00
Action time (UTC)	01.04.2016 17:00–19:00	03.04.2016 14:00–16:00	06.04.2016 05:00–07:00	09.04.2016 14:00–16:00	12.04.2016 06:00–07:00
Pvt1					
Pvt2					
Pvt3					
Pvt4					
Pvt5					
Pvt6					
Pvt7					
Pvt8					
Remarks	Summer time— UTC+2h	Summer time— UTC+2h	Summer time— UTC+2h	Summer time— UTC+2h	Summer time— UTC+2h
Purpose of DR	To flatten the consumption peak	To see how much they are willing to reduce their comfort while at home	To flatten the consumption peak	To flatten the consumption peak	To flatten the consumption peak. The lowest required temperature.

As conclusion, if results shown here could be achieved in real terms, on a daily basis, flattening of consumption peaks would be achieved. Therefore, the purpose of the DR program would be accomplished.

9.3.5.4 Demand response—lessons learnt

- The utility is performing DR program for peak shaving on its supply side. Expected savings should be used to cover incentives to the customers who successfully fulfill DR condition and to partially cover the investment in smart installation needed to pursue DR actions. Customers shift their consumption toward before or after the DR interval. Utility's intention is not to reduce the consumption in general, but to shift it from the peak interval. If the overall consumption decreases a lot, the whole DR concept might be endangered.

- Installation in 8 private homes consists of the following: thermostatic valves, smart thermostat, smart plugs, magnetic door/window sensors, motion detector, thermometer, humidity meter, lux meter, and gas smart meter. Each system measured overall gas consumption and partial electricity consumption (smart plugs).

- Initial installation costs for smart homes and smart installations used in the project are very high to justify its feasibility, in iURBAN that was done on purpose, to test and prove usability of different components. In further cases, if only DR is objective, the installation cost should be kept low—just GW and remote thermostat. Thus, utility can co-finance that investment from future savings based on DR actions. If customers want more functionality, the rest of installation could be bought by them.

- Customers reacted very well, but probably also due to the fact that they knew they were part of a test. It is expected that, in the case of the long-term commitment, the level of successful DRs would be lower.

- The customer's feedback related to complexity of the DR process shows that the level of automation needs to be increased, especially on the customer's side, in order to make a viable use case => less interaction from customer needed. If the level of automation can be increased, we also expect that the needed financial incentives can be lower, as there is less discomfort for the customers to deal with the DR request.

- Customers have expressed their wishes to not interact, but they want to keep option to "overwrite" DR requests, i.e., to keep final control over consumption. On the other side, that would reduce savings on utility's side and lower the DR incentives. One further research question could

be directed toward exploring how often customers use the overwriting function.

- Number of customers included in the DR program was 8. The sample is quite small; the program needs to be tested on a larger scale to give more relevant results.
- Business case does not seem to be very favorable for gas, but maybe more for electricity. It strongly depends on saving potential, specific for each market/country. The most feasible gas DR program is viable only for customers who use gas for heating/cooling, where the consumption is significant enough and that leads to sufficient savings for utilities to finance investment and incentive costs.

9.3.6 Variable Tariff Simulation

9.3.6.1 The model

Variable tariffs are the basis of the implicit demand response (also called "price-based")[5]—consumers are responding to time-varying electricity prices that reflect the value and cost of electricity in different time periods. Consumers can shift their electricity consumption away from times of high prices and thereby reduce their energy bill. The economic benefits are duly described in Deliverable 6.2.

The CDSS software is also designed to allow the energy supplier to offer to its customers time-varying prices: Different tariff plans can be made through the CDSS and the supply can create/modify/delete tariff plans and can specify various attributes, for every tariff plan, like

- City: the city name where the tariff apply
- Tariff Name: the name of the tariff plan.
- Group: customer group to whom the tariff plan should be applied.
- Commodity.
- Unit: measure unit of commodity.
- Currency: The currency applied.
- Date/time period.

The software also allows for comparison of tariffs, getting information about tariffs costs (month by month) related to the last year.

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[5]Eurelectric Demand Response Report, p. 3; ACER, "Demand Side Flexibility: The Potential Benefits and State of Play in the European Union", ACER/OP/DIR/08/2013/LOT 2/RFS 02, available at <http://www.acer.europa.eu/official_documents/Acts_of_the_Agency/References/DSF_Final_Report.pdf>, p. 5.

9.3.6.2 Testing and validation in the pilot of Plovdiv

As with demand response, the implementation of time-varying tariffs is not an option currently in Bulgaria for the customers participating in iURBAN project, although they have the technical equipment (i.e., metering devices taking data at 15-min intervals) to be able to participate in such a program.

The EWRC approved the tariff time zones in the seasons according to which different tariffs apply—day and night tariff for the household customers, and day, night, and peak tariff for the non-household once.[6]

Tariff zones for **non-household** customers:

November–March		April–October	
Day	6.00–8.00	Day	7.00–8.00
	11.00–18.00		12.00–20.00
	21.00–22.00		22.00–23.00
Night	22.00–6.00	Night	23.00–7.00
Peak	8.00–11.00	Peak	8.00–12.00
	18.00–21.00		20.00–22.00

Tariff zones for **household** customers:

November–March		April–October	
Day	6.00–22.00	Day	7.00–23.00
Night	22.00–6.00	Night	23.00–7.00

Thus, variable tariffs currently cannot be tested in Plovdiv since there are tariff zones (day and night tariff) approved by EWRC. Furthermore, in accordance with the Energy Act, the EWRC sets mandatory quotas for certain types of producers on the basis of which the public supplier—NatsionalnaElektricheskaKompania EAD (NEK)—sells electricity on the regulated price to the end supplier (supplying with electricity customers on the regulated market).[7] The energy suppliers buy electricity on a flat rate from NEK which is regulated by the EWRC.[8] EVN end supplier cannot sell electricity to customers at a price below costs because this qualifies as dumping and the company will be sanctioned by the competition protection commission.

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[6]Price Decision Ц-002 of the State Energy and Water Regulation Commission as of 29.03.2002.

[7]See Article 21, para 1, point 21 of the Energy Act in connection with Ordinance on the Regulation of the Prices for Electricity.

[8]Article 15, para.2, point 2, of Rules for Trading with Electricity issued by the Energy and Water Regulation Commission, in force as of May 9, 2014.

Apart from the fixed time zones when tariffs apply, there is another limitation on the implementation of variable tariffs—the metering device in place of the customer. Although the customers participating in iURBAN project have metering devices allowing remote and hourly metering, not all customers in Bulgaria have such meters installed. On the liberalized market, customers which do not have the technical facilities for hourly metering have standard load profiles. Thus, variable tariffs actually cannot be applied as there are standard consumption curve applicable for the month. Furthermore, the Energy Regulator also in its decision from 2013 ruled that installation of smart meters is not mandatory and it is up to the grid companies to decide whether they would invest money in that.

In conclusion, there are two limitations on the implementation of variable tariffs in their strict sense and in the forms as described in Deliverable 6.2— regulatory and technical. As the different types of variable tariffs require frequent data gathering, this is a test for the remote metering system and communication. In a more simplified form, we can actually say that the day and night tariffs are a form of variable tariffs and as such have been tested within the iURBAN project. As the customers participating in the project, pay their energy according to the prices determined for the two tariffs by EWRC.

9.3.7 Consultancy Services

Lastly, to offer consultancy services to the end consumers can be an applicable business service for municipalities or third-party operators. Especially, municipalities or other local or regional authorities or organizations have typically a number of big buildings with many employees or visitors, such as schools, kindergartens, public libraries, and city council. The number of people that are frequenting these buildings is usually quite high, but these people do not pay for the costs of energy consumption, which increases the risk of inefficient consumption behavior. Therefore, if the municipality is operating the smartDSS, it can critically analyze the consumption patterns within the buildings and detect any sources of inefficiencies (e.g., heating or lighting at night or during weekends) or high consumption devices that might be turned off or replaced. Furthermore, optimal heating patterns can be established through smart heating devices or specifically educated energy managers for the building can be trained to keep inefficient consumption low. Necessary investments in better insulation within the building can be detected as this is oftentimes a major source of energy inefficiency, especially in countries such as Bulgaria and Croatia. In general, these services can raise awareness about consumption patterns and might positively influence

behavior as a consequence. Private customers might benefit especially from these services as they reduce their overall energy costs.

If the characteristics of consumption exhibit certain peaks throughout the day/week or any high-load devices are existing, e.g., heat pumps or air conditioning, it might be financially profitable to engage in certain demand-side management measures. This could be

- Participation in specific demand response programs that are tailored toward the characteristics and needs of the building and consumers.
- Switching from fixed tariff rate to dynamic tariff if a high price responsiveness can be obtained, e.g., through the installation of smart devices that are able to shift/store loads or the appointment of an energy manager for the building.

Offering consultancy services is also a possible business service for third-party operators, as these can specialize in connected business models and build up further competencies. It is less applicable for utilities, specifically energy retailers, as their business model is based on selling as much energy as possible.

Potential benefits for the market actors can therefore be

- Possibility to make decisions about investment in better insulation within the building.
- Raising awareness about high consumption devices within the building or other sources of additional energy consumption, e.g., open windows.
- Detection of unnecessary consumption devices, e.g., lighting at night, air condition.
- Establishment of optimal heating patterns within the building, e.g., turning off heating at night or during times of vacancy.
- Decisions about investment in further smart systems, such as smart heating installations, automated air conditioning.
- Evaluation of profitability to take part in specific demand response programs, e.g., direct load control.
- Switching from fixed to dynamic tariff if high price responsiveness can be obtained, e.g., through smart devices or appointment of energy manager.

9.4 Conclusion and Policy Implications

In this chapter, we have outlined the outcomes from the testing and simulation of the selected use cases pertaining to general business case of the iURBAN project. Following the review made, it could be concluded that the use of

CDSS assists the daily business of utilities, municipalities, and probably also energy managers and creates new opportunities for their business models in the sense of providing the ground on which new services can be built (e.g., city energy view, technical loss) or providing opportunities for cost reduction (e.g., demand response), or allowing grid expansion without investment in new infrastructure (VPP and what if analysis). The analysis made for the European replicability also supports that and outlines the current situation with market enablers and obstacles for major European markets.

Consequently, the utilities will need to adapt their business models to capture the opportunities created for them by the new technologies and respond to the demands of their customers, which are becoming more active players in the new energy systems. In turn, municipalities will also need to amend their city policies to be in line with their citizens' needs or expectations. Energy and facility managers also compete on a rough market and offering services with added value such as smart energy management will give them competitive advantage. Thus, ICT tools such as CDSS comes as a right ally to help its end users to respond more adequately to the needs of their customers/citizens and position better on the market.

Data-driven technologies such CDSS will play important role in the energy systems, which are now undergoing transformation and become more and more digitalized. However, it becomes evident in the course of the project implementation, that certain use cases (such as demand response) could not yet be implemented in the pilot cities due to the regulatory and legal restrictions.

Therefore, the penetration of new technologies and the development of a sector such as the energy should go hand in hand with the reformation of the legislation and sufficient communication to the end users. Besides that, adequate protection of personal data and sensitive information (such as consumption pattern or way of bill payment) should be ensured. Through the implementation of use cases in the pilot, it has been highlighted that creating general understanding and knowledge in customers about innovative technologies is equally important for their acceptance and actual implementation as it had been the case with the pilot of Plovdiv (city energy view) and Rijeka (demand response). Finally, a European market for energy services can be created if there is a level of harmonization of national laws is achieved allowing the energy systems to function in similar market-based way and safeguarding the personal data of end users.

The implementation of the business cases of the CDSS calls for harmonization across the EU and corresponding changes in the legislation in different Member States, allowing the implementation of new technologies along with

the demand response and dynamic tariffs which helps customers save energy, money, and GHG emissions.

The following general needs regarding adjustments in the regulatory framework have been identified in the pilot cities:

- Allow the flexibilization of tariff schemes, i.e., the implementation of dynamic tariff for end consumers and private households. This can both help to prevent critical load situations and the implementation of new innovative energy services. So far, grid fees and most other energy price components remain fixed, which hinders forwarding incentives down the value chain. The price regulation for customers on low voltage should be abandoned together with the firm fixation of the tariff plans.

- The participation of third parties in the energy sector is mostly not possible yet, e.g., for demand response aggregators or other service providers. Opening the market for new entrants should facilitate further innovative energy services, which in turn can increase the awareness of consumers about energy efficient behavior.

- It is recommended to enable regulatory innovation zones or settings that invite for experimenting with ICT measures and new business models. Investments into innovative smart energy tools are hindered by a high degree of uncertainty regarding the regulatory framework as well as a general lack of transparency with the decisions of the regulator in the energy sector.

- Existing balancing options are focused solely on generation. The integration of demand response measures can constitute a cost-efficient alternative. The inclusion of DR at the electricity spot market and ancillary service market is recommended to allow for effective business cases related to demand response. At the same time, pooling of different demand resources should be made possible in order to reach the necessary threshold and size regarding the minimum requirements at the different energy markets if prequalification for balancing energy can be made at the aggregated pool level.

- The communication between a presumably increasing number of market actors and with a large number of consumers should be made easier regarding the communication infrastructure. Therefore, we recommend the consideration to adopt communication standards for smart infrastructure from an early point on, e.g., the open ADR standard to standardize demand response events between different market actors with heterogeneous smart grid infrastructure. In general, technical communication

standards for the IT infrastructure could significantly reduce transaction costs for involved market actors and facilitate connected investments. Policy makers might encourage the use of such open standards by incorporating them in their digital agenda.

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