



Smart Energy Management

Sustainable cities and buildings

With the number of people living in urban areas increasing, supplies of raw materials diminishing, and temperatures rising worldwide, cities are set to face some major challenges over the next few years. Cities are responsible for two-thirds of global energy consumption, 60 per cent of total water consumption, and 70 per cent of greenhouse gas emissions. And they continue to grow. Already, more than

50 per cent of the world's population lives in towns and cities. By 2050 this figure will have risen to as much as 70 per cent. So it is in cities that the battle on climate change and pollution will be won or lost. The most important challenge will therefore be to make urban development sustainable. This requires sustainable buildings, because buildings currently account for more than 40 per cent of global energy use, and hence

21 per cent of all greenhouse gas emissions. This in turn requires transdisciplinary solutions, in which not only the building, but also mobility, energy-generating equipment and infrastructure, are equally taken into account. KNX city shows how such holistic solutions can be incorporated into sustainable cities, and how they interact with the building.



BUILDINGS

What will the building of the future look like?

The building of the future will be energy-efficient and capable of communicating with its environment (the smart grid).

Cities can only be sustainable if the individual buildings are energy-efficient. The building's energy management system will be monitored quantitatively by smart meters. Based on this information steps can then be taken to improve the energy efficiency not just of the building itself, but also of the entire district, or even the city as a whole.

Solution with KNX Energy Management

KNX already offers solutions today for smart metering, electric vehicles, improving energy efficiency, power generation management, load/tariff management, and communication between buildings.

MOBILITY

How will we get from A to B in the future?

In vehicles powered by renewable energy.

Mobility is becoming more and more important, and in future a large percentage of all vehicles will run on electricity. But electric vehicles are only worthwhile if their batteries are charged exclusively with renewable electricity. Solutions therefore need to be found for charging electric vehicles with renewable power from either on-site generating systems or the local power grid.

Solution with KNX Energy Management

KNX offers solutions already today for using e. g. the surplus energy from on-site photovoltaic systems or smaller scale wind turbines on buildings to charge electric vehicles 100 per cent with renewable energy.

INFRASTRUCTURE

How will energy use be managed in cities in the future?

Energy will be managed at a multi-building level, taking account any decentralised power generation systems.

Infrastructure is becoming more and more important. Already today it is clear that no one solution will be capable of overcoming all of the challenges facing our energy supply. These challenges are the result of the increasing use of renewable energy in general, and decentralised power generation in particular. Many different disciplines will need to work together to create a single overall solution from numerous individual solutions.

Solution with KNX Energy Management

KNX already offers solutions today that use communication technology and IP/internet to link up buildings on separate sites as though they were a single building.

POWER GENERATION

How will we produce energy in the future?

Mainly renewably, in other words from sun and wind.

The world is on the cusp of a major shift in the way it produces and uses energy. As energy is obtained increasingly from unpredictable renewable sources, the great challenge will be to keep energy supplies reliable. Many utility companies will in future manage loads indirectly by charging tariffs variable in time, in order to motivate customers to switch power consumers on or off at particular times of day.

Solution with KNX Energy Management

KNX already offers load management solutions today that address the problem of fluctuating power supplies from photovoltaic systems and wind turbines.



KNX city – the sustainable city

What form will communication take in cities in the future?

Information and communication technology (ICT) will be an essential element of smart grids and infrastructure in the future. ICT is a vital component of the holistic solution needed to create a sustainable city. KNX will provide all of the interfaces needed between the city of the future and smart grid communications infrastructures, itself becoming an integral part of the smart grid. Because it brings together buildings, transport, energy generation and infrastructure in a holistic way, KNX can already offer innovative solutions today for making cities more sustainable while exploiting the potential of transdisciplinary approaches.

BUILDINGS

Advantages

Energy savings

- KNX shading control: 40 % saving
- KNX individual room control: 50 % energy saving
- KNX lighting control: 60 % saving
- KNX ventilation control: 60 % saving



Energy-efficient buildings are the cornerstone of sustainable cities

Energy-efficient buildings are at the heart of any sustainable city. KNX offers a wide range of solutions for improving the energy efficiency of all kinds of buildings, from private homes to large company premises. These include load management concepts, which always involve sensors and actuators. The sensors gather information, for example consumption figures, or information on the status of a given component, while the actuators respond to this information by triggering an action. Actions can include making or breaking an electric circuit, turning on or off a device such as a heat pump or a household appliance, or switching on or off more conventional power consumers. KNX energy actuators are particularly useful devices here, because they not only measure the power consumption of electric circuits,

but also switch them on or off. KNX touch panels enable the control of various household appliances to switch them on or off electronically. This represents a major benefit over other systems, as of course simply turning the power on or off is not sufficient to properly start up or shut down a typical domestic appliance. KNX also offers a wide range of interfaces for intelligent connections between a KNX system and a heat pump. Wall-mounted home charging points for electric vehicles can also be integrated into KNX networks via actuators, enabling the charging process to be started or stopped from a KNX touch panel. If the building has its own micro power plant, for example a photovoltaic system, any KNX connected charging points can be configured to charge the vehicle using only electricity produced on-site.

MOBILITY

Advantages

- Electric cars can be integrated into KNX intelligent building control systems
- KNX makes charging electric cars more eco-friendly
- KNX can control the discharge of electric car batteries according to the amount of power needed by the smart building



With KNX, electric cars are an integral part of intelligent buildings

For a city's electricity supply, electric vehicles mean an increase in power consumption. Not only that, but electric cars are likely to use the most electricity in the evening, as drivers return home from work and plug their vehicles in to be charged overnight. This happens at a time when private households use the most electricity anyway, so the additional demand from electric vehicles will pose a threat to the city's reliability of supply. This is because nearby transformers could become overloaded, but also because the excess demand calls for additional generating capacities. Electric vehicles are likely to stand unused over-

night for longer than it takes to charge their batteries. In principle it should therefore be possible, instead of charging them in the evening, to charge them at night or even in the very early hours of the morning. This would help considerably to spread the load more evenly over a 24-hour period. Where different electricity tariffs apply at different times of day, it can even make sense to stop or start the charging process at specific times so that charging takes place when electricity is cheaper, or to make maximum use of the power generated by an on-site photovoltaic system.



INFRASTRUCTURE

KNX links up different houses and buildings with one another

Advantages

- KNX can network buildings with one another
- KNX can be used to manage consumption
- KNX incorporates smart grids into intelligent building control systems



KNX infrastructure solutions allow several buildings within a city to be networked with one another as though they were just one building. In the sustainable city of the future this can be very beneficial, for example for building operators or housing associations responsible for several different buildings or sites. If a building operator has already a micro power plant (e. g. photovoltaic system) on one site and would like to build a car park for electric vehicles at a second site, this KNX solution can be used to ensure that the vehicles are only charged if the power plant at the other location is generating enough

electricity. The KNX infrastructure solution is of course also suitable for controlling all traditional KNX applications. The sustainable city of tomorrow needs a seamless flow of communication from the power grid to the city, on into the building or household, and back to the grid. In the sustainable city of the future KNX will be responsible for communication at building level and will also provide all necessary interfaces to the smart grid to facilitate tariff management, power generation management, load management and, where relevant, storage management throughout.

POWER GENERATION

Renewable energy is an integral part of any KNX-controlled smart building

Advantages

- KNX reduces fossil fuel consumption
- KNX increases the use of energy from on-site power plants
- KNX coordinates the use of renewable energy resources between different smart buildings



Renewable energy is constantly gaining in popularity compared to traditional energy sources. But renewable energy sources fluctuate, producing electricity only when, for example, the sun is shining or the wind is blowing. This poses challenges for electricity grids. If, for example, on a sunny day electricity is fed into the local grid from photovoltaic systems in quantities far exceeding the load on the grid (i. e. the demand for electricity) at that time, this can cause voltage problems. The other way around, if there is a demand-supply gap because demand is high at a time when renewable power generation is missing or collapsing, this gap must be filled by electricity from conventional power stations that need to be started up at short notice. One potential solution that is frequently discussed is the storage

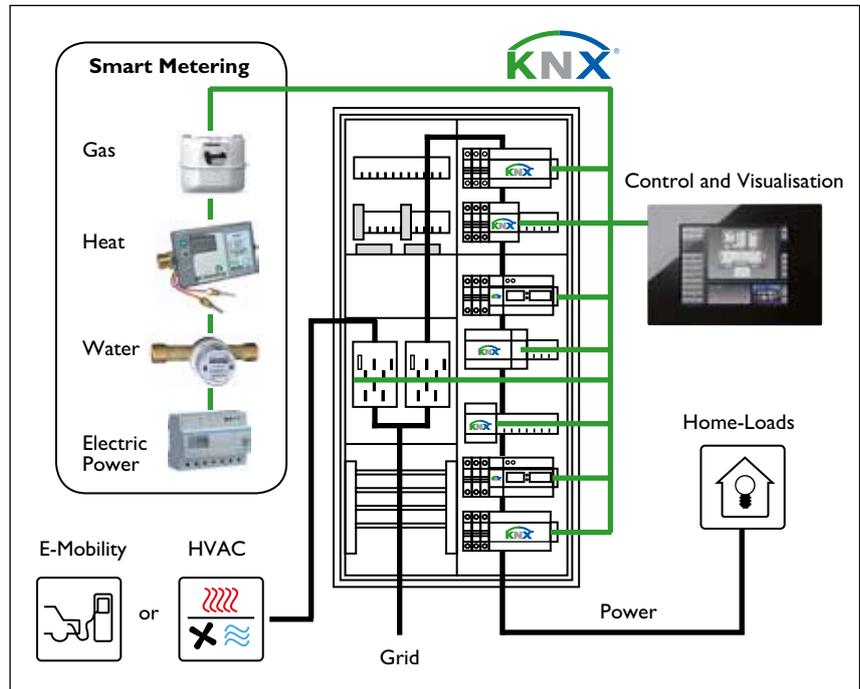
of electrical energy. However, it is hardly realistic to store electricity on the kind of scale necessary. In future, power generation management and load management will therefore be essential. KNX offers load management solutions that permit the adaptation of conventional electric loads and electric loads from HVAC systems, white goods and electric vehicles according to the amount of renewable energy generated by the building, or in response to a electricity tariff fluctuating in time (determined by the amount of renewable energy produced in that section of the grid), without any loss of comfort or convenience. All solutions available so far have had one thing in common: that they can interact with each other within the building, but not with the outside world. KNX will change all that.

Smart metering

KNX smart metering is at the core of KNX city

Energy transparency throughout the building

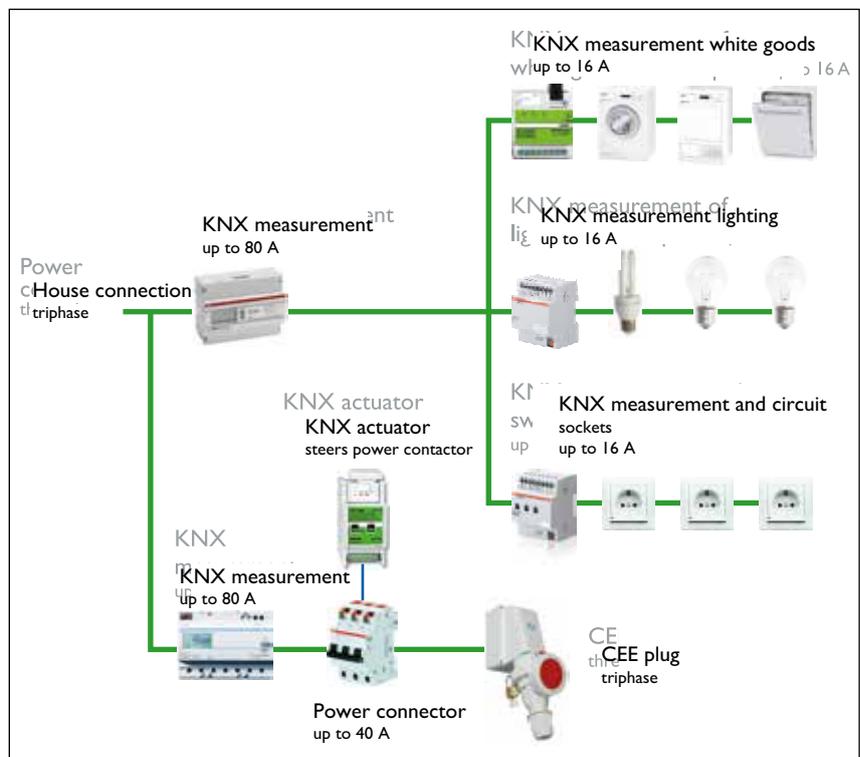
“Energy management” can be defined in different ways depending on the perspective (i. e. when viewed in relation to the building or the city as a whole). In buildings, energy management helps both to save useful energy such as electricity and heat, and to reduce consumption of gas and water. The first step in energy management is for building users to take a more conscious approach on how they use resources. Those who have access to clear information on current rates of consumption will use energy and water more carefully. At present the standard technology for obtaining this information is the smart electricity, heat and water meters provided by suppliers. The numerous KNX smart metering components available give users greater transparency over their consumption and spending. A wide range of KNX meters and actuators with current detection is also available, for use in application-specific smart metering solutions.



KNX offers sensors and actuators for every possible application. The picture shows a typical topology for a KNX installation in a main distribution board, including electricity meters for e. g. general consumption, HVAC applications or electric vehicles, and power generation.

Optimising consumption

Visualising energy consumption data alone is not enough to actively improve a building’s efficiency. Ideally, in addition to consumption data, information on the weather, on indoor temperatures, on whether windows and doors are open or closed, on whether people are present, on room use, and other relevant data should also be available. Only with detailed information can interpretations be made about the building users’ consumption behaviour and potential for reducing consumption. If this information is available it can then be used to optimise consumption, either manually or automatically. KNX solutions can gather energy data and then either visualise them, or trigger automated processes in response to them. This is active energy management. It gives users constant access to consumption data and triggers automatic processes to improve a building’s energy efficiency.



Smart electricity metering

Smart grid

Interaction between KNX and a smart grid

KNX city highlights innovative solutions that will in future make it possible to use renewable energy with no loss of comfort or convenience and no price increases.

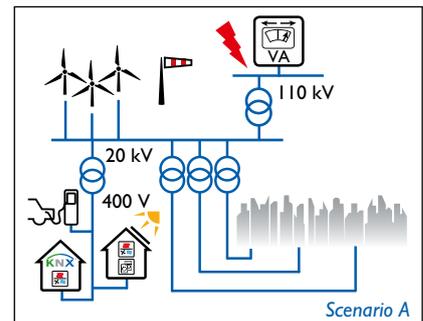
For this to be possible, the KNX solution must encompass not just individual buildings, but also the local and city-wide power grids and their energy management systems.

In KNX city, KNX communicates with the smart grid. Four scenarios from the daily life of a city of the future are presented below. Potential problems are explained, and details are provided on how KNX responds to each scenario.

Scenario A: Surplus of renewable energy

It is night-time: the load on the city's grid has dropped to its lowest level, but because of strong winds large quantities of renewable energy are being fed into the grid. The city must somehow absorb this excess electricity. All intelligent houses and apartments are therefore informed

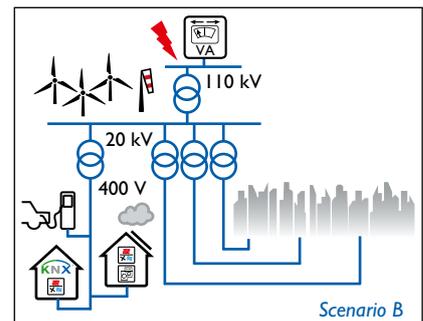
of the surplus via communication technology. They can then switch on KNX-connected consumers such as white goods and electric vehicles. In this way KNX is able to again balance the city's energy supply.



Scenario B: Insufficient renewable energy

This situation can be seen as the reverse of scenario A. KNX city shows how, for example, the amount of power fed into the grid from wind turbines can drop in the morning time (due to low winds). The city needs to react to this situation by reducing the load on the network,

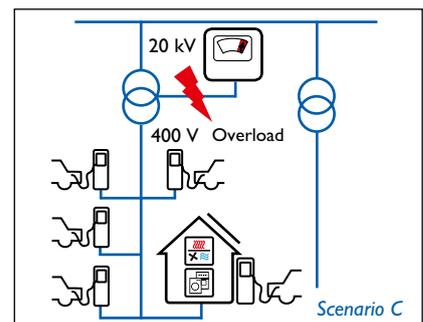
which it does with the help of KNX. KNX turns off electric vehicle charging points and white goods, and switches the air conditioning system or heat pump over to 'eco' mode. In this way KNX is able to prevent blackouts by again balancing demand and supply.



Scenario C: Peak load across the entire city

The load on the grid is at its highest in the evening because that is the time when the city's residents cook their dinner, use more light, and switch on TVs, stereos and white goods, causing a load peak. This situation is worsened by increased energy use by the service industry and commuter transport ser-

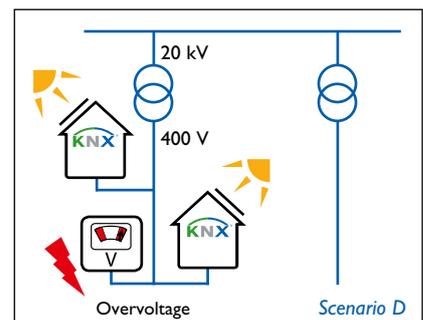
vices. Even with renewable energy fed into the grid, electricity bottlenecks can occur at these times. Like in scenario B, here KNX is able to reduce the energy demand of KNX connected consumers. Energy stored in the batteries of electric vehicles can even be fed back into the grid if necessary.



Scenario D: Local increase in voltage

Photovoltaic systems feed energy directly into the low-voltage grid. Particularly around lunchtime, this can cause the supply of renewable energy to exceed demand, which can result in voltages rising to unacceptable levels. The problem can be solved if smart homes and apartments are connected to a smart energy supply,

as this allows the load to be increased locally. This is done by switching on KNX integrated consumers (e. g. white goods and electric vehicles) or increasing the load drawn by them (e. g. by switching air-conditioning systems or heat pumps over to "comfort" mode).



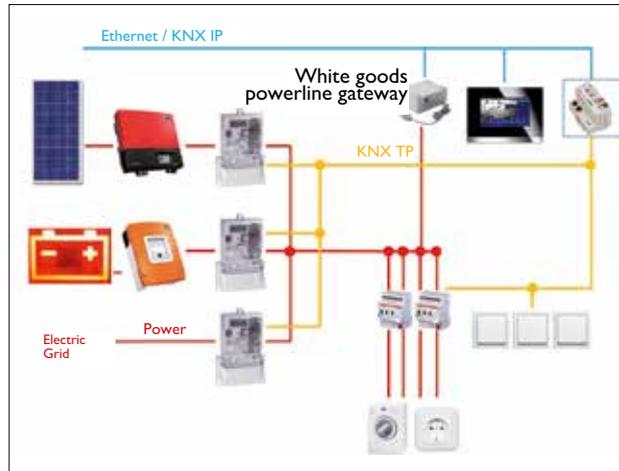
KNX city – the solutions

BUILDING

Example I: Demand Side Management

The challenge

Traditionally, the amount of electricity produced by a power grid is adapted to the actual energy demand. Different kinds of power plants – base load, medium load and peak load power plants – operate at different times depending on the load, to ensure that the right amount of electricity is always generated. Fluctuating renewable energy sources, on the other hand, have the disadvantage that they cannot produce on demand: if more power is suddenly needed, it is not possible to simply start generating electricity. With renewable energy, the traditional model of demand-based control does not work. This can cause problems in terms of reliability of supply, particularly if more renewable energy sources are used and at the same time conventional fossil fuel power stations are closed down. One possible solution that is currently discussed is the 'smart grid', which uses information and communication technology to vary electrical loads as energy production fluctuates. The challenge is to create a KNX load management system that can vary the building's electrical loads according to the amount of electricity generated on-site, or in response to changes in energy prices over the course of the day.



KNX load management: An algorithm stored in a KNX PLC ensures that loads and domestic appliances are switched on and off in harmony with the building's on-site photovoltaic system and, where relevant, electricity storage capacities, with simultaneous submetering via KNX energy actuators.

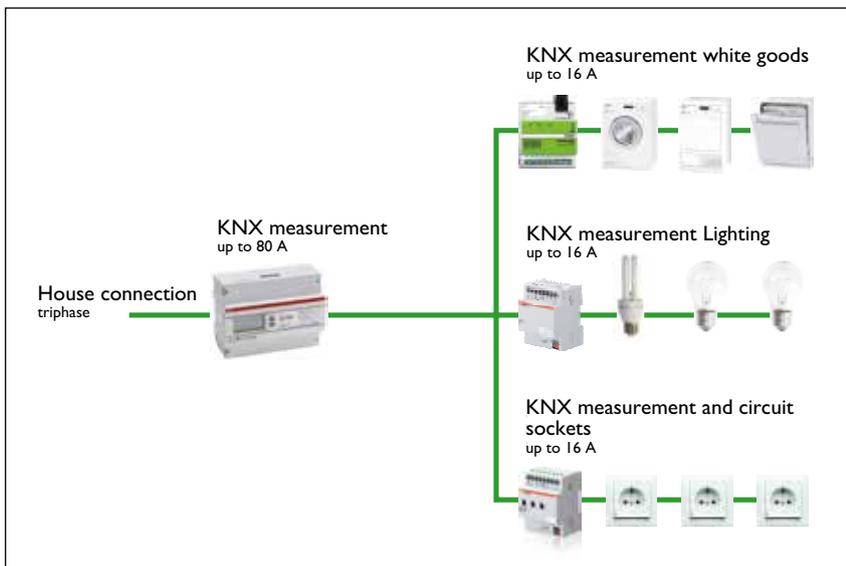
The solution

To adjust loads effectively, sensors are needed that can measure both the amount of electricity consumed, and any power generated by a photovoltaic system. This can be done by either KNX DIN-rail meters or KNX integrated smart household meters. In addition to the sensors, actuators are needed to connect and disconnect loads, e. g. switch domestic appliances on and off. For standard loads, KNX switching actuators can be used, while for more sophisticated loads such as white goods and HVAC systems, special KNX interfaces need to be used to switch these devices on electronically.

Practical implementation

Sensors: Overall metering is ensured by Smart electricity meters (electronic domestic supply meters). In addition to these, KNX DIN-rail meters collect consumption data from individual sources.

Actuators: Conventional loads are controlled by switching actuators. Energy actuators (from e. g. ABB or Siemens) are a convenient solution, because they not only switch loads on and off but also measure, thus combining sensor and actuator functionality in a single unit. Household appliances are connected by Powerline to a KNX panel (from e. g. BJE). Air conditioning units are connected to KNX via the appropriate KNX interfaces.



Functions

- Adaptation of loads to amount of electricity generated on-site
- Adaptation of loads according to electricity price

Advantages

- Household appliances can be connected to KNX via their Powerline interface. This is a far more elegant solution than simply cutting their power supply.
- Saves money by taking advantage of the lowest tariffs
- High degree of automation

**Example II:
Tariff based management**

The challenge

In future, the conventional electricity meters used by energy suppliers will be replaced by smart meters. This is essential for calculating the amount chargeable to customers with variable electricity tariffs (which vary according to the amount of renewable energy produced in a given section of the grid), because meters will need to measure not only the total amount of energy used and produced in kilowatt-hours, but also the amount of energy consumed and produced (e. g. by a photovoltaic system) every second. These smart meters also have a customer interface. To benefit from a KNX load management system it is necessary to input the tariffs in KNX.

The solution

A variety of options are available for integrating smart meters into KNX:

KNX wired sensor

The meter is connected to KNX via its optical customer interface.

KNX RF interface

Here a KNX RF interface sends the data directly to the KNX bus. The KNX RF signal can be converted to KNX TP using a media coupler.

Direct KNX meter

This smart meter features a direct KNX TP interface

Practical implementation

Two possible solutions are presented below:

KNX wired sensor

A wired sensor is mounted on the optical customer interface of the electricity utility meter (magnetic contact). The sensor is connected via a KNX device



Smart household meters for photovoltaics and related systems, including KNX submetering

with the KNX bus and continuously communicates the data to the KNX bus.

KNX RF

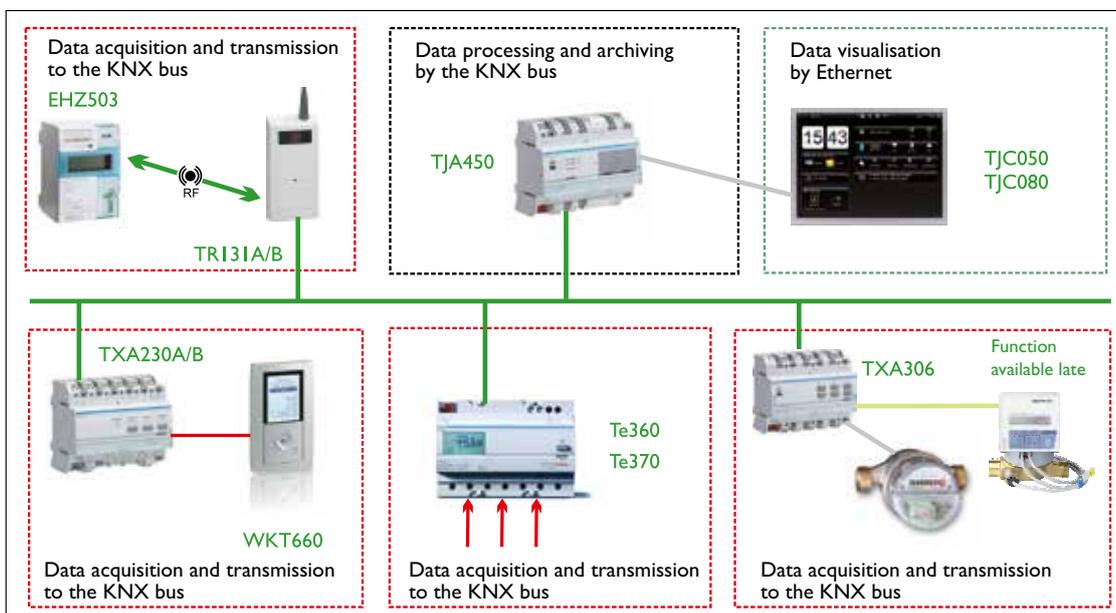
Here a Hager KNX RF interface is connected directly to the smart electricity meter and sends the measurements wirelessly to the KNX bus. Using the Hager Domovea unit, the data can then be visualised on any other KNX panel. In addition the metering values can be used by KNX actuators for controlling electrical loads.

Functions

- Informs the KNX system of the amount of power currently produced (PV) and the current electrical load
- Sends energy generation and consumption data to KNX
- Visualisation

Advantages

- Data from meters can be sent wirelessly or via cable
- No additional measuring sensors needed, as for conventional electricity meters
- Allows automatic adjustment of electrical loads by KNX
- Advantageous for power grids as large amounts of electricity fed into the grid from PV systems does not increase the voltage in the grid: the additional power generated is absorbed by load increases motivated by lower electricity prices.



MOBILITY

The challenge

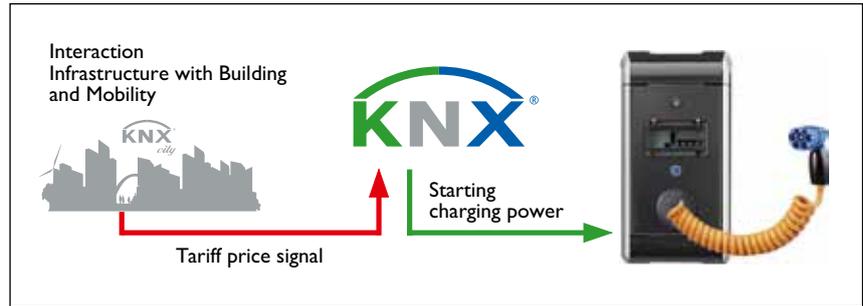
For many years, growing international demand for oil coupled with a finite supply of petroleum resources has been driving oil prices higher and higher. The private transport sector is pinning its hopes on electric vehicles as a way of managing the world's dependence on oil. But for a city's electricity supply, electric vehicles mean an increase in power consumption. Not only that, but electric cars are likely to use the most electricity in the evening, as drivers return home from work and plug their vehicles in to charge overnight. This coincides with the time when private households generally use the most electricity, so the additional demand poses a threat to reliability of supply.

The solution

Electric vehicles are likely to stand unused for around 10 hours overnight – considerably longer than the 3-5 hours it takes to charge their batteries. In principle it would be possible, instead of charging them in the evening, to charge them at night, for example in the very early morning hours, which would take considerable pressure off the grid. Where different electricity tariffs apply at different times of day, it can additionally make sense to stop or start the charging process at specific times so that charging takes place when electricity is cheaper.

Practical implementation

For the connection of eCars to KNX, a pilot box can be used. With this device KNX telegrams can be indirectly sent to the eCar. With the telegrams, the eCar can start or stop the charging, or can vary the charging power. A KNX switching actuator controls the pilot box. Depending on the signals, the pilot box changes the PWM signal and trans-



mits the information to the vehicle. The switching actuator needs to connect the operating voltage of the pilot box in different combinations with the four predefined inputs of the pilot box. Two of them are used to control the charging power (S3, S4). The charging current can be set to 6 A, 10 A, 16 A or 32 A.

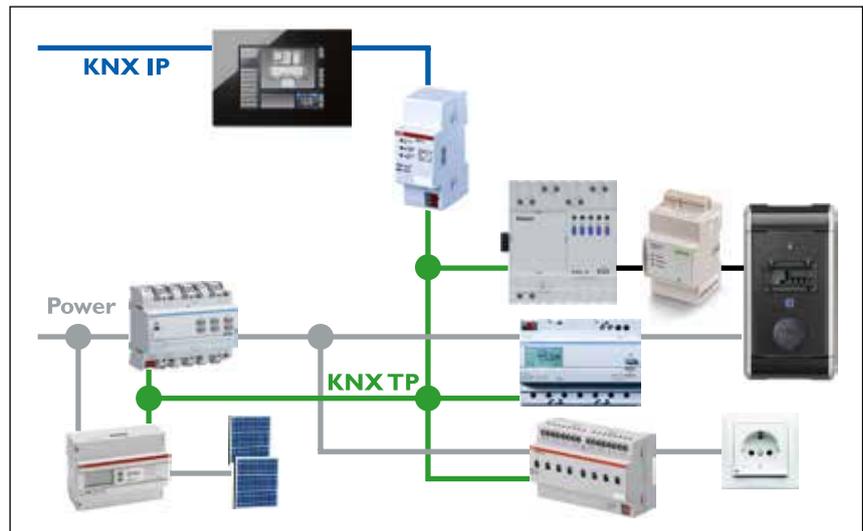
Functions

A KNX integrated charging post gives the building control system control over one of the largest and most energy-intensive loads in the home. If electricity is in short supply, the charge contactor can be opened to reduce the load or, if this is supported by the vehicle and the charging post, energy can even be fed back into the grid. If variable electricity tariffs

apply, the charging process can be activated and deactivated depending on the current price. The charging process can also be started immediately from a KNX panel, for example if the driver needs his car again imminently.

Advantages

Even just a small number of electric vehicles being charged from the grid is enough to cause a local transformer overload. But if the charging post is integrated into a smart home or apartment that receives information from the smart grid when a transformer is close to overload, this can be prevented by quickly stopping the charging process. In the same way KNX can also take advantage of a surplus of power in the grid by resuming charging.



INFRASTRUCTURE

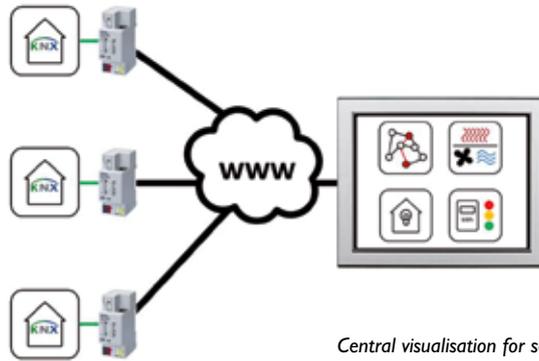
**Example I:
Buildings on separate sites**

The challenge

KNX has solutions already available today that use communication technology and the internet to link up buildings on separate sites as though they were a single building. This is particularly relevant for housing associations that need to manage several buildings at once, or companies with buildings at locations scattered across a city.

**Solution/
practical implementation**

KNX IP routers are used to connect each building's KNX TP line with an IP network. If the KNX IP router is part of a network with internet access, a secure VPN tunnel connection can be established over the internet between that building and other buildings with KNX IP routers.



Central visualisation for several individual sites

Functions

Incorporating several buildings into a single KNX installation makes it easier to gather measurements for accounting and billing purposes. It also permits the visualisation of all KNX functions at one or more central locations.

Advantages

This solution brings consumption and feed-in data together at a central point for accounting purposes. It also makes it possible for a single energy management system – for example a system for turning down the heating or air conditioning in offices at weekends – to span several sites. A range of systems and sites can be visualised, managed and monitored remotely via an existing network or over the internet (VPN connection).

**Example II:
Heating, AC and ventilation systems**

The challenge

To keep energy supply and demand in equilibrium even when the load on the grid is at its highest, cities need electrical loads that can be temporarily reduced or disconnected. Because space heating and air conditioning are responsible for a large percentage of urban energy use, only a slight change of the set point temperature can make a big difference to the amount of power available in the grid as a whole.

The solution

Heat pumps and air conditioning systems are normally controlled according to a set point set by the user. Room thermostats compare the current temperature with the thermostat setting (setpoint) and turn the heat pump or air conditioning unit up or down in order to reach it. If the heat pump or air conditioning unit is connected to the KNX bus, the setpoint can be adjusted automatically.

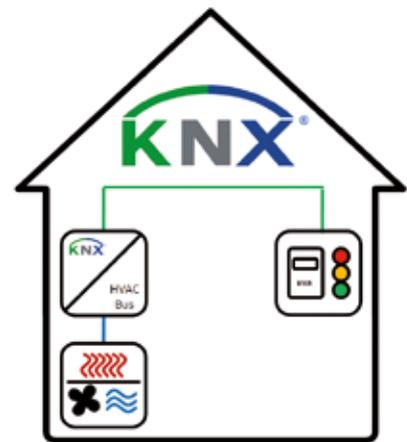
Practical implementation

Users can store a range of temperature setpoints in a KNX panel, for example 'comfort temperature', 'standard temperature' and 'eco temperature'. The preferred setpoint can then be trans-

mitted via a gateway (e. g. Theben or Zennio) to the heat pump or air conditioning unit.

Function

The room air conditioners can be turned up or down depending on the current load on the grid. If the load is very high, for example, the setpoint for the heating or air conditioning can be switched to 'eco'. This immediately reduces the amount of energy needed by the heat pump or air conditioning system. The other way around, when the load is small or there is a surplus of power on the grid, the setpoint can be switched to 'comfort temperature'. This increases the load on the grid and



improves the comfort of those people living or working in the building.

Advantages

Integrating a heat pump or air conditioning system into KNX allows buildings to adapt their electrical loads to external signals, for example a signal indicating the load on the grid or the current electricity price. As both the share of renewable energy and electricity consumption in general increase (due to electric vehicles), this kind of reactions will be crucial for maintaining a steady power supply.

ENERGY GENERATION

Example:
Monitoring and maintaining photovoltaic systems

The challenge

Photovoltaic systems are generally made up of several parallel rows – or “strings” – of modules. In the worst case scenario, this means a faulty module can put the entire string out of operation. Unless the system is regularly monitored, faults of this kind can go unnoticed for a very long time. This KNX solution can monitor PV systems both with and without solar tracking, and record all relevant data.

The solution

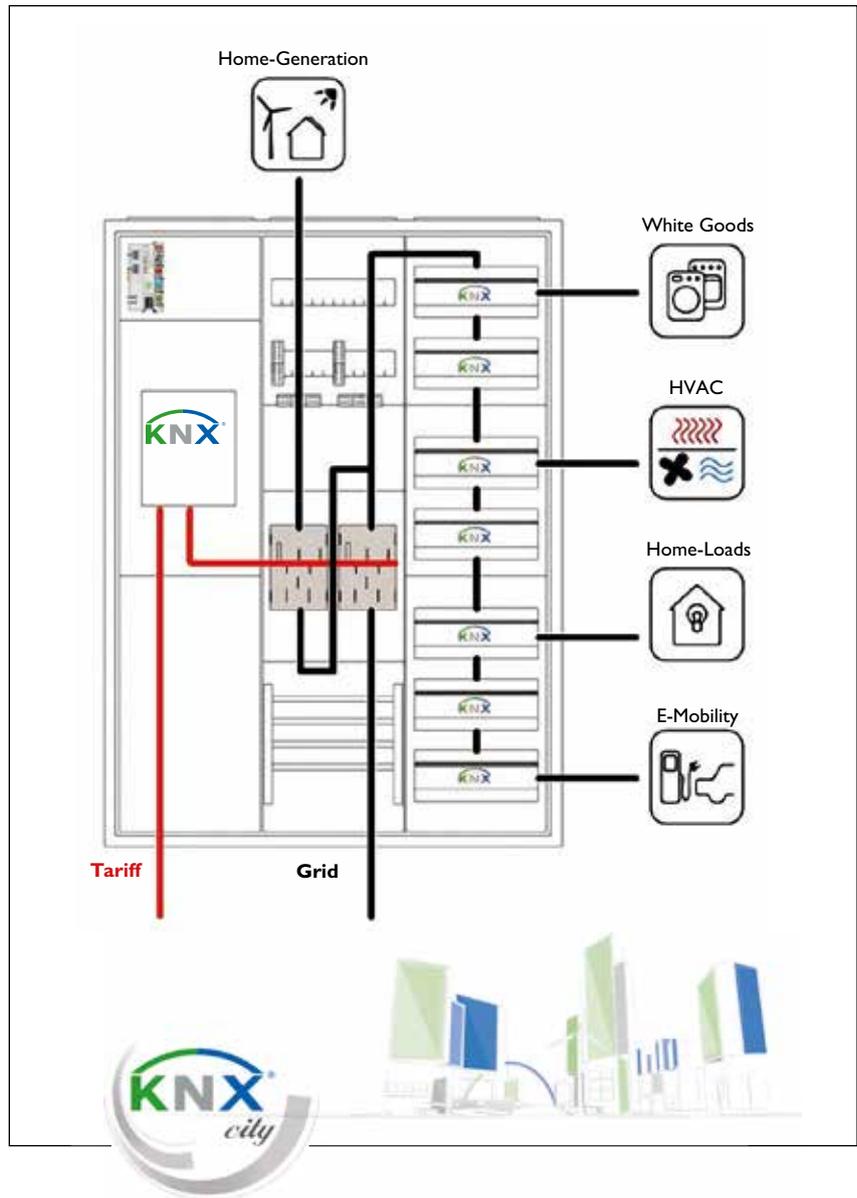
Many PV inverters even measure the AC current generated internally in the inverter. The standard models available on the market use RS232/RS485 ports for this purpose. KNX technology can directly access these ports and send the measured data to the KNX bus. This allows users to see where dirt has accumulated that could reduce the efficiency of the system, as often happens particularly in the case of flat modules.

Practical implementation

The photovoltaic interface (e. g. Synapsi) gathers the measured values that are then transmitted to KNX. The other way around, measured data from KNX are also sent to the photovoltaic system. KNX weather stations and pyranometers are particularly important, because the measurements from these devices can be used in remote maintenance for checking that a given string is e. g. not faulty, but merely in the shade. KNX temperature sensors measure the temperature of the modules, to notify users of any instances of overheating due to faults, and hence prevent fires by providing early warning. If a fault does occur, alarm signals are sent by UMTS to the remote maintenance point and KNX.

Functions

- Real-time monitoring of the function of all components in photovoltaic systems
- Data are collected at regular intervals
- KNX manages log files from several different systems



- Comparative analysis of current power generation and installed capacity
- KNX manages all technical and consumption data gathered for use in subsequent maintenance/servicing work

Advantages

In future a portion of the electricity in grids will be fed in from local photovoltaic systems. This will create challenges for electricity grids. Particularly in low-voltage networks, large amounts of power fed into the grid can cause voltages to exceed the acceptable lim-

its. Another problem is that energy suppliers and operators of distribution networks cannot know how much power is being fed in by what systems at any given moment. KNX can help here by permitting the management of several photovoltaic systems together. Armed with information about these systems, electricity suppliers and network operators can then apply load management and tariff management strategies to encourage end customers to adapt their electric loads to the amount of power currently being produced.