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WHITE PAPER
AUXILIARY NETWORKS AND DEVICES

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1. INTRODUCTION

This white paper is one of a series of thematic white papers covering various aspects of electrical installations in houses, flats and residential units. They are aimed at architects, designers, specification writers, decision makers and students.

When designing an electrical installation for the home it makes sense to also consider other networks and electrical devices besides the usual 230V mains for power sockets and lighting. For example, consider installing wiring for speakers or charging facilities for the electric car. A check is also required as to whether a Wi-Fi data network can be installed without a wired data network and whether structured cabling has been used. The design might also include a few small devices to make life easier and more comfortable for the residents. Finally, in this white paper we look to the near future by asking if we should store the energy generated by our solar panels for use when the sun isn't shining, and a little further into the future by considering the merits of a separate DC network in the home.

2. A FEW SMALL DEVICES

Let's get started with a few small modifications to the design of the electrical installation.

2.1. USB SOCKETS

The days of the portable cassette recorder, and the constant supply of batteries needed to operate it, are far behind us. Today we use all kinds of mobile devices such as smartphones, GPS units, MP3 players, digital cameras, tablets, cordless bluetooth speakers, etc. These devices all have an internal rechargeable battery which implies a need to recharge the devices regularly.

Until recently, each device came with a charger. The connection to the unit was almost guaranteed to be device-specific. For instance, the charger for your mobile phone did not fit your daughter's, because it was another brand or model. And forget about using one kind of charger to recharge another type of device, such as an MP3 player. In other words, no more phone calls or listening to music when we leave the house without the proper charger.

The European Community now obliges manufacturers of mobile devices to provide their products with a universal connection for chargers. Manufacturers opted for the USB Type A connection. A new mobile device probably still comes with a charger, but the box will definitely also include a cable with a universal USB plug at one end. This enables you to charge your mobile devices using a USB connection without having to use various different chargers. This can be a big advantage to the user - that is unless you have to start up your computer first! However, there is a solution.

2.1.1. USB CHARGERS IN THE WALL

Most manufacturers of switches carry a USB socket in their range. A flush-mounted box, of the type used for ordinary power sockets, is used to fix these devices in the wall. The USB socket requires only a 230V connection. The sockets usually have between two and four USB connectors, each supplying 5V DC to charge different kinds of mobile devices. These USB sockets supply power only and are never used to transfer data. Some manufacturers supply an ordinary 230V power socket combined with a 5V DC USB connector.

Figure 1: A combination wall socket with integrated USB charger
(Photo source: Busch-Jaeger)

The major advantage with these USB chargers is that they do away with the need for the right charger and free up the ordinary power socket for other electrical devices.

2.1.2. Where are they fitted?

USB sockets can be fitted in several places in the newly built home. The living room, study, kitchen and bedrooms are the obvious places. Be sure to fit them where they are easy to reach: near a table or cabinet where the device can be placed while charging.

In existing homes, the ordinary power point can be replaced with a USB socket; however, if it is regularly used, it would be better to fit a combi-device: a 230V power point and USB connector combined.

2.2. Space-saving Radios

We like to listen to the news or the traffic information at breakfast time, or to music while cooking in the kitchen, or working in the garage, and some of us like music in the shower. These pleasures always rely on a radio or some other music-playing device. However, radios for background music and information also take up cabinet, shelf or table space, space which many of us simply don't have because we want other things on our shelves, cabinets and tables.

If the device relies on batteries, they will need replacing every once in a while. A device of this kind will often be portable, but moving a radio around the house is also inconvenient. Devices that require a 230V supply must therefore have a power socket..

2.2.1. Radios in the wall

More and more switch manufacturers offer radios that can be mounted on the wall. The radio and a speaker combined are no bigger than a double socket. As with ordinary power sockets, they are fitted in flush-mounted boxes, and they are finished in the same colours and materials as the switches and sockets. This means that the radio no longer takes up space on a cabinet or shelf.

This type of radio is also powered by a 230V cable, which also serves as the radio's aerial. In other words, there is absolutely no need for additional wiring. As a result, the system can be fitted anywhere in an existing home where a horizontal or vertical double power socket already exists at operating height. If so desired, the speaker can be concealed in the wall at a different location. When two speakers are used the radio automatically switches from mono to stereo.

Figure 2: The radio and the speaker combined are no bigger than a double socket.
(Photo source: Gira)

The radio unit features a touch screen, which is used to switch it on or off, set the volume or pre-set a favourite station. It goes without saying that other radio stations can also be selected. The display shows the station's frequency. If the device is RDS enabled, the name of the station will also be shown. The time is also displayed.

In many cases an external source can be connected to the radio, such as an MP3 player. Some brands offer a docking station for a smartphone. Not only can the smartphone be charged, but it can serve as an external music source. What's more, the internal clock can be used as a timer to switch the radio on and off automatically.

3. SPEAKER WIRING

Residents who want to enjoy their music from the sofa, or listen to a film in surround sound, will have to fit speakers. If no wiring has been provided for the speakers, this will present a problem. Speakers will eventually be fitted, but the wiring will run along the wall and over the floor - not an attractive prospect for a new build or recently renovated home. From time to time wiring may even be pushed under the carpet, to hide it away. This will create a bump, which can be seen or felt in the carpet. It also increases the risk of tripping, or even falling.

3.1. ACTIVE AND PASSIVE SPEAKERS

Passive speakers are usually used in homes. These are connected to the speaker outputs of an amplifier by means of a flexible twin-lead wire (two insulated conductors) and usually have an impedance rating of either 4 or 8 ohms. The separate amplifier sends the electrical audio signals through the wire to the speakers.

In certain cases, active speakers are used, which are equipped with a built-in amplifier. Active speakers must be connected to a power source, which is usually a power socket near the speaker. These are sometimes equipped with bluetooth or a docking station so that they can be driven directly by a device such as a smartphone. In other cases, a line-in jack is provided for connecting a CD player or a tuner.

3.2. DIFFERENT MODELS

In addition to free-standing speakers that can be placed on the floor, on a cabinet, on their own stand or mounted on the wall, there are also many types of built-in speakers. The latter can be installed either in the wall (including hollow walls) or in the ceiling. The main advantage of built-in models is that they save space: they never get in your way, and the wiring is always invisible. Outdoor speakers are also available for use on a patio or in the garden.

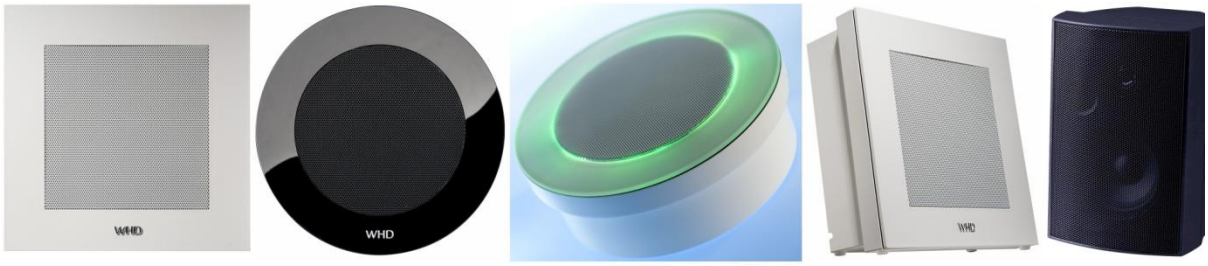

Figure 3: Speakers come in all shapes and sizes, finishes and types, including outdoor variants. (Photo source: WHD)

3.3. THE RIGHT PLACE

As our ears are only directionally sensitive to high tones, the location of the subwoofer (low tones) doesn't matter as much. But positioning is important for the other speakers. That usually means facing them toward the spot where a person will be listening to music. The advantage of mounted speakers that can be affixed to a support is that they can be turned to face the right direction. When positioning built-in speakers, the location of furniture is an important factor. It's not really such a great idea to place a tall cabinet in front of a speaker. Ceiling speakers do not present this problem. Be aware, however, that the optimum listening area for ceiling speakers is much smaller than that for wall-mounted or free-standing speakers, where the sound arrives horizontally.

3.4. WIRES AND CONNECTORS

There are red and black terminals at the back of the amplifier for each speaker. The same colour code is used on the backs of the speakers. Connect black to black and red to red. The best way to avoid mistakes is to use 'speaker cables'. These consist of two conductors, one with black insulation and the other with red.

The diameter of the wires being used is also an important consideration. The fact that weak current is involved does not mean thin wires can be used. On the contrary, if the wires are too thin there will be a loss of power along the cable, and this will ruin the sound quality. The recommendation is for a wire diameter of 2.5mm² over a maximum distance of 50m. The diameter should be increased for even longer distances.

Connectors with gold contacts are only used in certain high-end audio systems in order to maximise signal transfer. However, there is no agreement among manufacturers that this actually yields a difference that is audible to the listener. For standard home applications, and for the majority of people who do not have ultra-sensitive hearing, the standard and far less expensive contacts should suffice.

4. WIRED OR WI-FI NETWORK FOR THE HOME?

These days we carry all kinds of wireless devices around with us and many are in communication with each other. That said, not everything is wireless, and wireless technology presents a few drawbacks. When building a new property, or renovating an old one, it is best to provide a wired network, alongside a wireless one, for your desktop PC, network printer, network hard drive, multimedia streamer, smart TV and the set-top box for your digital TV. Here's a short list of the pros and cons for each network.

4.1. WIRED NETWORK

Advantages:

- Very reliable communication, at any time.
- Its operation is not impacted by other devices or its surroundings (i.e. neighbours).
- High speed—multiple simultaneous users on the same network do not impact speed.
- High protection against outside (cyber) attacks.
- Relatively low price.

Disadvantages:

- Devices need to be connected at fixed locations. For instance, working in the garden with the laptop is not an option. There is only limited flexibility for the user (constrained to certain locations).
- It cannot be used on devices that have only a wireless connection.

4.2. WI-FI NETWORK

Advantages:

- The user can use wireless devices anywhere inside the home. In certain circumstances the devices can also be used in the garden.
- Wi-Fi can be a solution in those places where no wired connection is available.

Disadvantages:

- It cannot be used for devices with only a wired connection.
- Less reliable, depending on the circumstances.
- It is difficult to assess its range beforehand. This depends mainly on the materials used inside the building. Wooden panels do not block radiation quite so much.. Concrete walls, aluminium windows and heating radiators can weaken the signal up to 90%, causing the range to diminish quickly and hamper communication. Installing a repeater can solve the issue when the range is too low.
- Wi-Fi is still many times slower than a wired network. Speed can drop significantly during simultaneous use.
- The quoted speed is never the speed of your data traffic. It requires so-called overhead traffic to establish communication between wireless devices and the router and this can take up a significant part of the total available bandwidth.
- It is possible that other devices that operate at the same frequency (microwave, DECT phones, baby monitor and other Wi-Fi networks on the same channel, etc) can have a disturbing effect.
- There is less protection against outside (cyber) attacks or use.
- Some people believe that electromagnetic radiation can have a negative impact on health but there is still no scientific proof of this. However, scientific research revealed that there is a negative impact of Wi-Fi network radiation on leaves of certain types of trees.
- The price of a Wi-Fi network may turn out to be higher than that of a wired network.

4.3. WHAT NEEDS TO BE IN PLACE?

In an existing home the choice will soon lean towards a wireless network, unless there is a good case for additional wiring and it can easily be installed. In a new build, however, you should always go for a wired network and a complementary wireless network for your mobile devices.

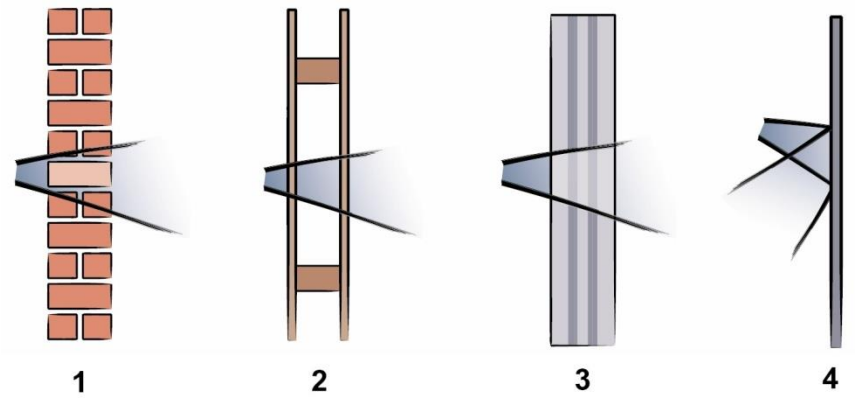

Figure 4: The materials used for walls, ceilings and floors can seriously reduce the range of wireless systems: 1. Stone walls: 20% to 40% loss. 2. Wood and plasterboard walls: 5% to 20% loss. 3. Reinforced concrete: 40% to 90% loss. 4. Metal and steel: 90% to 100% loss. (Illustration source: Niko)

5. STRUCTURED CABLING

Homes often contain several separate networks, each with its own wiring and connection points. Consider, for example, the ethernet cabling for the computer network, the telephone wiring for the phones, the coax cabling for the television and radio, the speaker wiring, and so on. Once these separate networks have been installed, modification is no longer possible. A connection for a television always remains the same, even if we move the television to another space or another room.

We can improve the situation, however, by using structured cabling. Essentially, this means using the same type of cable for the TV, for data transfer and for audio, video and telephone signals. The connectors are also all the same. Each cable connects to a central location on a patch panel, containing passive and active components. This means that, from that point on, the resident can decide whether a wall socket will be used to hook up a television, a data network, the telephone, audio or video systems. Flexibility is guaranteed.

5.1. STAR TOPOLOGY

A variety of networks use the star topology. This means that a separate cable runs to a central point from every connection point on the wall. Take the data network in the home, for example. Every desktop computer, network printer, network hard disc, etc, has a connector of its own on the wall. A separate CAT5 or CAT6 cable runs from every connector to a central connection point. At that point the cables are linked with connectors to a hub, modem or router. In other words, every device in the network is connected through its own, dedicated cable.

5.2. STRUCTURED CABLING

We can give a significant boost to the flexibility of the installation as a whole by using structured multimedia cabling. In practice, this usually means a shielded cable containing several twisted pairs (TP). Occasionally, one of these twisted pairs is shielded separately and is then used to carry TV and video signals. Every multimedia cable leads to OmniMedia wall sockets, usually in the form of an RJ45 jack. On the other side, the cables run to connectors on a patch cabinet. The cabinet contains multiple active components such as the router, TV splitter, home phone exchange, audio or radio splitter or amplifier, etc. By selecting the connectors in the cabinet, the user is free at any time to decide the use for each outlet, such as internet, telephone, TV, satellite, music, etc. In other words, today's TV connection may serve as tomorrow's telephone connection. The user is entirely free to associate a signal with the outlet of his or her choice. This flexibility comes in especially handy when a resident wants to move the TV away from its original location or suddenly needs a telephone or internet connection in a particular space.

Figure 5: Multimedia cabling like this is used for the installation as a whole.
(Photo source: Abitana)

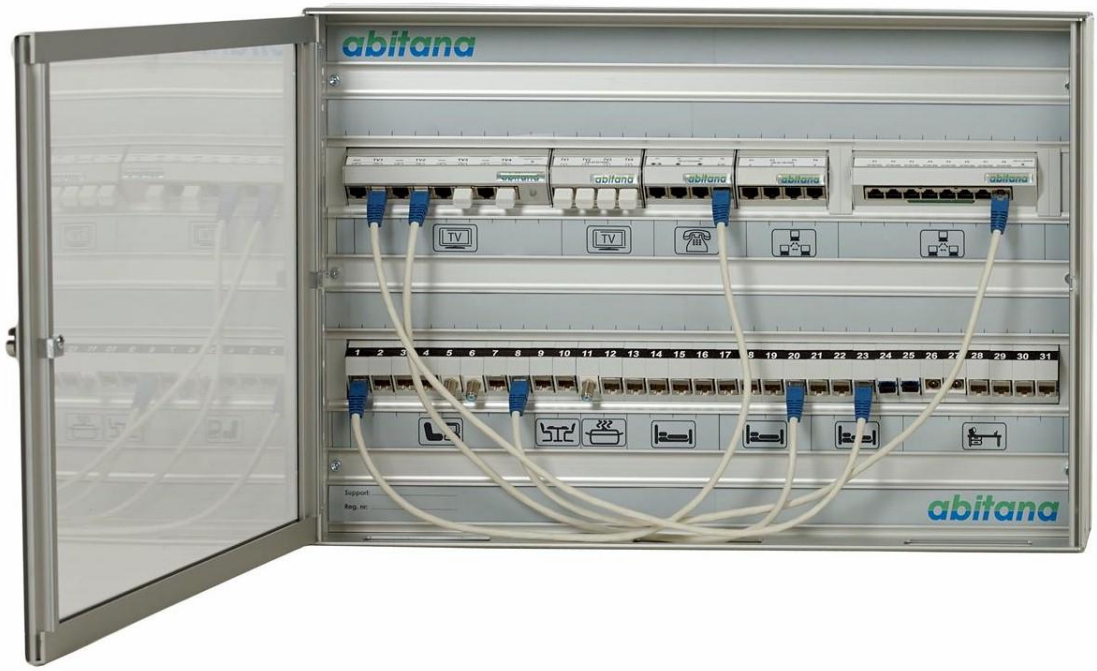

Figure 6: Example of a patch cabinet containing active and passive components. The resident chooses the function of each outlet and is free to change the function at any time according to need.
(Photo source: Abitana)

5.3. THE FOUNDATION

Structured cabling is as much a foundation to the home as the bricks, floors, windows and doors. It is recommended that flexibility be incorporated into your internet, telephone and multimedia networks, wherever possible, when building a new home or undertaking a thorough renovation.

6. ELECTRIC VEHICLE CHARGING POINT

Nowadays the electric bicycle is a common sight during the work commute or in traffic during off-peak hours. However, we are now seeing a rise in the number of electric scooters (significantly quieter these days) and electric cars. All of these forms of transport need to have their batteries charged. Where and how is this done?

Figure 7: Electric cars are on the increase.
(Photo source: Smart)

Charging a bike or scooter is usually not a problem as the standard wall socket will usually suffice. Many people are under the impression that a straightforward cable, plug and domestic power socket are enough to do the job for the electric car. This is true, but the method has a few serious disadvantages, including the charging time.

In 2016, after the pilot stage and the market launch, we are now at stage 3 of the electric car: the volume-driven market. The number of people driving electric vehicles is only going to increase, which is why it is so important to provide the home with what's needed for optimal charging of the electric car.

6.1. DIFFERENT KINDS OF ELECTRIC CARS

There are currently several different kinds of electric vehicles. They range from micro, mild and full hybrids to plug-in hybrids with a range extender and a fully electric car. It is the latter two types that consume the greatest amount of electricity. The plug-in hybrid with the range extender has a small fossil fuel engine which serves as a generator providing a supplementary battery charge. This increases the practical range of the vehicle. Full electric vehicles no longer have a fossil fuel engine.

6.2. THE HOME AS A CHARGING STATION

Cars with fossil-fuel engines have their fuel tanks filled en route. It's not quite the same for electric cars. They are filled while they are parked in the street, in the car park, at the shopping centre, at work or at home. The time they take to charge depends on several factors. The amount of charge left in the battery plays a part, but then so does the charging connector. A monophasic connection to a standard 16A/230V (3.7 kW) power socket can take several hours (sometimes up to 11) for a full charge. A multiphasic connection to a 400V/32A (22.0 kW) socket reduces the charging time considerably. It makes sense to modify the charging capacity of the home charging station to suit the vehicle. A home charging station with a large charging capacity of, say, 22 kW, offers the greatest flexibility. It will charge every electric vehicle, whether it carries a 3.7 kW, 7.4 kW, 11 kW or 22 kW charger. This means that family and friends can also stop by to charge their vehicles.

6.3. THE HOME ELECTRICITY CONNECTION

In most cases the maximum power of the home connection is limited and it is often too small to charge the car in a short space of time. In this case we might opt to install greater maximum power, preferably with a multiphasic connection.

6.4. THE VARIOUS PLUG TYPES

Charging plugs come in two types: types 1 and 2. In 2011 the type 2 plug was globally adopted as the world standard. It can be used for monophasic and multiphasic connections and currents of 13 to 63A. Another handy feature is that the type 2 plug allows energy to flow from the power grid to the vehicle and from the vehicle's battery to the power grid. The latter is particularly useful if the home is fitted with solar panels. Unused solar energy can be stored in the battery of the car. But when there is little or no sun, the energy stored in the car's battery can be made available to other household users. In 2017 all electric cars will be fitted with a type 2 connector cable.

6.5. A HOME CHARGING STATION FOR THE CAR

We have all seen the charging stations in public car parks and at the supermarket, the workplace or the hospital car park. This type of charging station is usually equipped to deliver a large quantity of energy to the car battery in a short space of time.

Some manufacturers now offer charging stations for use at home. These units are fitted in the garage and are equipped to handle the voltage required. Besides delivering a rapid charge they protect the battery against overcharging. Some models also offer a wireless network connection (Wi-Fi). This allows the user to start, stop or pause the charge by means of an app on a smartphone or tablet. These charging stations also offer a number of charging modes to help reduce charging costs or maximise the use of home-generated solar power. They can be used in periods when the power grid rate is cheapest. Consumption can be recorded and monitored by the charging station or through the app.

Figure 8: A charging station in the garage offers many advantages.
(Illustration source: Mennekes)

7. ENERGY STORAGE IN A HOME DC NETWORK

Let us bring this white paper to a close by taking a look at the home electrical installation of the near future.

7.1. A QUICK BRUSH-UP AC AND DC

Alternating Current (AC) is the sinusoid tension with a 50 Hz frequency that is currently found in most countries or the 60 Hz used in the US and parts of Asia. The current in a closed current circuit changes direction 50 or 60 times per second. The power grid to which our homes are connected supplies such a tension.

Direct Current (DC) always flows in the same direction. There is a polarity indicated with '+' and '-'. This is the current we find in the battery of the car, as well as all our mobile devices, such as smartphones, tablets, laptops, etc. The solar panels on our roofs also produce DC. In order to use the latter in an AC home environment, an inverter needs to transform the DC into AC.

7.2. ENERGY STORAGE

In the years ahead, the network feeding our homes with electricity will increasingly be under pressure This is due to the expected increase in the number of electric vehicles and heat pumps, combined with a higher penetration of electrical solar panels for homes. Solar panels pose a problem in that the energy they produce during the day, when there's ample sunshine, needs to be used at the same time it is generated. Storing that energy would enable us to use it in the evening or at night, reducing the amount of unutilized energy that is put on the public power grid.

Clearly, the need to store energy only arises when the home produces its own power too, usually through solar panels. Producing its own energy makes the home less dependent on fluctuating energy prices due to the load on the energy suppliers' power grid. A greater ability to use home-generated electricity also reduces the impact that overall price increases associated with using electricity from the grid might have on the monthly energy bill. It also makes the home less vulnerable to power outages. Some people even go to great lengths by making the energy storage capacity large enough so that they can be fully detached from the distribution grid.

7.2.1. BATTERY STORAGE

A battery is needed to store the unused energy generated by the solar panels. This would be something a little larger than the traditional 12V battery in a car that runs on a fuel engine. Batteries of 2 to 4.5 kW are available for home installations of 3 to 4 kW solar panels. It appears that the current standard is 2 kWh. There is no need to store all the energy as some is used at the time of generation.

Current batteries are Li-Ion models. They have a lifespan of about 3000 charge cycles, or 8 years when used for daily charging. Purchase prices are currently rather high (about 1500 €/kWh), but it is expected that prices will drop in the coming years to a level that attracts a broader market.

7.2.2. THE ELECTRIC CAR BATTERY

As we have said above, the battery found in an electric car can be used to store the unused energy generated by solar panels, provided the charging station is equipped to do this. This option is of particular interest to people who are often at home during the day. The unused energy is then stored in the car. When it gets dark, the energy can be used to power other electrical devices in the home. The user should, of course, make sure that the battery holds enough charge to drive the car the next day.

This is not a practical solution for anyone who is often out (in the car) during the day, given that the unused energy generated by the solar panels cannot be stored in the car.

Figure 9: The manufacturers of electric vehicles also offer batteries for home energy storage. (Photo source: Tesla)

7.3. A DC NETWORK IN THE HOME

An AC mains is usually installed in the home connecting all of the lighting, switches, power sockets and other devices. However, many of the devices that we use in the home run on DC (direct current) voltage. Just consider the wide range of mobile devices, as well as other electronic devices such as the computer, television, audio installation, not to mention LED lighting. Additionally, the electric car, electric scooter and electric bike run on DC as well. At the same time, the electricity we generate at home through our solar panels is also DC voltage.

All of these devices require converters and chargers. Converters convert the DC from the solar panels to AC for use in the home. We also use chargers for all kinds of mobile devices. They convert AC voltage into DC voltage for use in the device. Other devices, such as the television, have built in converters. To conclude: we generate DC, convert it to AC and then reconvert it to DC. That's quite a roundabout, unnecessary process: don't you think?

7.3.1. WHAT DOES THE FUTURE HOLD?

Actually, a first step towards installing a DC network in the home is to install a few USB sockets for charging your mobile devices. At present, however, these USB sockets still contain an internal AC/DC converter.

At a later stage we foresee the installation of a separate DC network alongside the existing AC mains. A central AC/DC or DC/DC converter can then be fitted to supply multiple power sockets with usable direct current (DC). The solar panels will then supply their DC energy to a DC/DC converter. This alters the current to make it available to every kind of DC device, and puts the Low Voltage Direct Current (LVDC) into an LVDC network with DC sockets (USB). At that point the lighting circuits could also be made into LVDC networks, assuming that only energy-efficient LED lighting is used.

We expect to see quite a few changes in the next 10 years, including the development of some pretty sophisticated products. Government subsidies could go a long way towards stimulating the roll out of DC networks. The industry is still currently working out the standards for LVDC networks.

8. USEFUL LINKS

Charging your mobile devices from the wall
https://pitchbook.copperwire.org/charging-your-mobile-devices-from-the-wall#

A space-saving radio for every room
https://pitchbook.copperwire.org/a-space-saving-radio-for-every-room#

Ever given thought to the wiring for your speakers?
https://pitchbook.copperwire.org/ever-given-thought-to-the-wiring-for-your-speakers#

Do you prefer a wired or wireless home network?
https://pitchbook.copperwire.org/do-you-prefer-a-wired-or-wireless-home-network-21000#

Is your home cabled in a structured way?
https://pitchbook.copperwire.org/is-your-home-cabled-in-a-structured-way#

Charging your electric car at home
https://pitchbook.copperwire.org/charging-your-electric-car-at-home#

Do you have room for a battery?
https://pitchbook.copperwire.org/do-you-have-room-for-a-battery#

A home DC network
https://pitchbook.copperwire.org/a-home-dc-network#