
International Children's Safety Service
Liveable Future Park
Generating Energy on-site with Renewable Resources
elmű·émász
e·on
ÉLHETŐ JÖVŐ PARK

The vision: living and working on an "energy island"

It is a bright summer day in 2011 in Fót, a small town north of Budapest. The clear blue sky together with the sunshine paints the Therapeutic Riding and Training Centre of the International Children's Safety Service in a good light, but thanks to the gentle breeze it is not too hot. The cheerful laughter of children preparing for their therapy session fills the air at the horse track, while in the background the murmur of the Mogyoród brook is heard, a beloved spot for hikers.

When I first visited the Therapeutic Riding Centre I was amazed. All the beauties of nature and the potential of creating a greener, healthier future in the new energy world can be found here – says Attila Kiss, CEO of E.ON Hungária Group. We took over the park with the integration of ELMŰ, and for us, this integration is about exactly what the center embodies, about creating value. Because we not only measure value in economic and financial terms, it is just as important for us to support the Hungarian society to the best of our ability. And the developments that have taken place here and will be continued in the future can set an example for us and all visitors to the results we can achieve together with attention and careful planning.

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It's fall 2020. There is a big hustle and bustle at the centre of the International Children's Safety Service as a small group of children is just preparing for their riding therapy session. Visitors will recognize immediately that something has changed during the past few years. A wind turbine in the background is instantly visible, and when crossing the little bridge at the entrance one can witness that the Mogyoród brook is no longer rushing down without any purpose: it drives a small water turbine before it continues on its way downhill. Moreover, the photovoltaic systems installed on the roofs of the buildings can be seen from a distance. They have been operating since 2012, and generated more than 512 MWh of electricity during these eight years, so they could reduce CO2 emission by over 310 tons.

The Fót Therapeutic Riding Centre has recently become a little "energy and research island", tells **Dr. Péter Edvi** Chairman of the International Children's Safety Service. But there is much more than just the installations you can see. Thanks to the devoted work of ELMŰ-ÉMÁSZ Group there is perfect harmony between the energy generation, measurement and storage devices which have been implemented at the Centre. As a result, the Fót Centre was upgraded with a complex system that is now almost independent from the large power stations and the public electricity grid.

Along with the Visitors' Centre which consists of and combines advanced technologies, insulated walls, doors and windows, we have installed an outdoor lighting system with LED-based street lamps equipped with movement detection sensor. In course of the landscaping work we have installed in the parking facilities a number of charger stations for electric cars. The chargers also rely on renewable energy. Fully-equipped work stations have been created for the researchers and students of the universities contributing to the development. In the end, all the hard and devoted work has proven to be successful: this project has been a unique one in Europe which set an example for others to follow, **Dr. Péter Edvi** says.

Implementation: the liveable future park

The cooperation between ELMŰ-ÉMÁSZ - part of the E.ON Hungária Group - and the International Children's Safety Service (NGySZ), and the Therapeutic Riding Centre operating under the aegis of NGySZ goes back many years. The commitment and faith of the top managers of both organizations has played an essential role in the development and maintenance of this fruitful cooperation.

ELMŰ-ÉMÁSZ has for long been supporting the activities of NGySZ as a key sponsor. In 2011 the cooperation between the two organizations entered a new phase when professional and charity considerations were merged in one single exemplary project. The idea of creating the Liveable Future Park and the innovative, brave response given to it has delivered real forward-looking solutions.

The Group's audit team started with an energy efficiency audit of the Fót Therapeutic Riding Centre in autumn 2011 to explore opportunities for the optimization of energy utilization and the identification of possible ways of increasing efficiency.

The feasibility study for the installation of the equipment using renewable energy sources was completed in early 2012 with the professional contribution of the Budapest University of Technology and Economics. While preparing this study, among others, meteorological data of the Fót region was also analysed. The main purpose of the document was to come up with a first estimate of the costs of the planned park.

Based on the results of the study, a proposal was made for the installation of photovoltaic system, wind turbine, and a micro-hydro power plant in order to respond to the electricity demand of the Therapeutic Riding Centre. However, renewable energy sources show significant fluctuations both on a daily and on an annual basis, which is incompatible with the facility's striving to be independent from the public grid. This is the reason why the experts recommended the procurement of an energy storage equipment in addition to the energy generation assets, which made the installation of a smart metering and control system (SCADA) essential as well.

Moreover, ELMŰ-ÉMÁSZ and the International Children's Safety Service aimed at using renewable energy sources for the heating, hot water supply, and cooling of the buildings. To this end, in the course of the project air-to-water heat pumps and solar thermal collectors were installed as well. Energy consumption of the buildings could be reduced simultaneously. All the buildings are covered with high quality thermal insulation and trilayer glazing with thermal insulation has been applied.

The next step was to make decisions regarding the site of the energy generation installations. At this stage certain site-specific features had to be defined, e.g. which building was the most suitable for the installation of the solar collector system based on its orientation and the load-bearing capacity of the roof. A minimum safety distance of the wind turbines from the buildings and gas pipes had to be taken into account as well.

Though, the implementation of the Liveable Future Park is far more than a self-serving endeavour. The creators of the project decided to make the facility accessible to the general public after completing the construction work. Accordingly, the plans included the construction of a Visitors' centre as well. The heating and cooling of the Visitors' centre is provided by an air-to-water heat pump. An intelligent energy storing system was installed in the facility as well, which – by co-operating with the monitoring system – helps in keeping the produced green energy in the park. Through this solution transmission loss can in a large part be eliminated. We have to count with transmission losses of 10% to 15% while electricity is transmitted from one of the Hungarian power plants (Paks, Mátra, Dunamenti) to the Fót Liveable Future Park, where the loss is depending on the distance.

Finally, ELMŰ-ÉMÁSZ decided to integrate the increasingly important idea of electric mobility into the concept of the Park. This decision was realised through the installation of charging stations with various types of chargers that can be used to charge electric cars. A number of the chargers are controlled by an intelligent system based on energy production, and what's more, in case of two chargers the power required for cars is generated practically in full by the solar panels located above the chargers.

Mercedes-Benz Hungária Kft. was happy to support this initiative. The car chargers are also suitable for charging Electro-Smart vehicles. HP Magyarország Kft. contributed to the implementation and development of a significant research environment by providing the IT infrastructure, while OTP Bank provided financial support.

Benefits of Local Green Energy Production

- energy production with own equipment will result in significant savings and independence from prevailing energy prices
- there is substantial independence in the field of energy supply
- locally produced energy can also be used for hot water production
- surplus amounts of electricity – where no storage capacity is available – can be fed into the grid, this way generating additional revenues
- it is an environment-friendly way of energy generation, there is neither carbon dioxide emission nor emission of other hazardous substances.
- no transmission losses occur because the energy produced is consumed locally

Challenges for Local Green Energy Production

- so as to set off the fluctuation in the availability of the renewable energy sources, a storage facility needs to be installed on-site
- installation of devices for continuous metering, control and automation is needed
- all installations should be connected to a smart control system in order to provide for an optimal and coordinated operation and for a reliable energy supply
- specific features of the site have to be taken into consideration in order to determine the appropriate energy mix and the optimal location for the installations

E.ON Hungária Group is the expert for energy efficiency and clean energy

One of our Group's success stories is the Liveable Future Park located in the area of the Fót Therapeutic Riding Centre. The facility contains practically all the installations which can contribute to the energy supply of the Park in an efficient, reliable, and effective manner, also adapted to the local conditions. An intelligent monitoring system coordinates the energy generation installations with the energy consumers of the Centre. The infrastructure of the park offers an ideal environment for the implementation of various innovation and research projects.

The Liveable Future Park includes the following Installations:

- buildings with quality insulation,
- small photovoltaic plants and hot water producing systems run by solar collectors,
- wind turbines,
- micro-hydro power plant,
- air-to-water heat pumps,
- battery-based energy storage and recovery system,
- smart energy control system,
- photovoltaic car shelters,
- electric car charging and energy recovery stations,
- various measurements, developments and prototypes which are important for the electricity grid,
- energy-saving LED-based, outdoor lighting solutions with movement tracking, smart control and solar panels,
- intelligent visitor information system (supported by Hewlett-Packard Enterprise),
- electric cars, mopeds and cycles.

The material displayed in the Visitors' Centre in Fót focuses on the themes of renewable energies, energy efficiency, decentralized energy systems, energy storage installations, smart grid solutions, and electric mobility. In addition, the Centre also serves as a venue for training courses, presentations, seminars, and workshops and research work. Registration for group visits is offered on ELMŰ-ÉMÁSZ website.

Installations using solar energy

Solar energy is essential for life on Earth. For that very reason, the use of solar energy is as old as mankind, however, the methods and technologies are constantly developing.

The solar energy reaching the Earth from the Sun would be more than enough several times to meet the entire energy demand of the world. The solar energy hitting the Earth's surface in 1.5 days is equal to the total amount of exploitable mineral oil resources of our planet.

There are basically two different methods of solar energy utilization: active and passive energy generation. Passive solutions are often applied in architecture e.g. when defining the orientation of a building or the types of building materials (so-called passive houses).

The two ways of active energy production are heat energy generation and photovoltaic energy generation.

In the course of heat energy generation, solar energy is transmitted by the solar collectors to a heat absorber. Typical areas of utilization include secondary heating for buildings and hot water production.

On the other hand, photovoltaic systems convert solar radiation directly into electricity.

In case of both methods the amount of energy generated largely depends on the orientation and the angle of inclination of the panels, and also on the geographical conditions.

In the Fót Liveable Future Park the experts of ELMŰ-ÉMÁSZ installed a small photovoltaic system consisting of 65 solar modules with an overall capacity of 15.6 kW and a solar collector-based hot water production system on the south side of the white stable's roof. The network connection for the photovoltaic module is provided by a three-phase inverter. The installations apply both methods of active energy production simultaneously, while the heat pump supplies the wash-basins of the white stable with hot water.

A display placed on the external wall of the stable provides precise information about the current performance of the system, the electricity generation to date, and also indicates the amount of carbon dioxide emitted since the commissioning.

The International Children's Safety Service installed several new photovoltaic systems from its own funds and from Environment and Energy Operational Programme (Környezet és Energia Operatív Program/KEOP) tenders due to the efficiency of the photovoltaic and solar collector systems installed on the stable. They also plan to install further devices utilising solar energy.

Key Facts of the Photovoltaic System installed on the white stable

Type of PV system	German PV with polycrystals
with polycrystals	240 W
Nominal Capacity per Panel	240 W
Number of Solar Panels	65
Installed Capacity of the system	15.6 kW
Inverter type	Fronius IG+ 150 V3
Inverter Capacity	12 kW
Overall Surface of the PV System	Approx. 100 m^2
Date of Installation	09.2012

Key Facts of the Photovoltaic System installed on the yellow stable

Type of PV system	German PV with polycrystals
Nominal Capacity per Panel	270 W
Number of Solar Panels	130
Installed Capacity of the system	35.1 kW
Inverter type	Fronius Symo, 2 pcs
Inverter Capacity	35 kW
Overall Surface of the PV System	Approx. 200 m2
Date of Installation	10. 2017
Date of Installation	09.2012

Key Facts about the Photovoltaic System installed in the office

Type of PV system	German PV with polycrystals
Nominal Capacity per Panel	250 W
Number of Solar Panels	92
Installed Capacity of the system	23 kW
Inverter type	ABB Trio
Inverter Capacity	20 kW
Overall Surface of the PV System	Approx. 140 m2
Date of Installation	07.2014

Key Facts of the Photovoltaic System installed on the Visitors' Centre

Type of PV system	German PV with polycrystals
Nominal Capacity per Panel	260 W
Number of Solar Panels	129
Installed Capacity of the system	33.5 kW
Inverter type	ABB Trio
Inverter Capacity	28 kW
Overall Surface of the PV System	Approx. 200 m2
Date of Installation	09. 2015
Date of Installation	09.2015

Presentation of photovoltaic car shelters

Adjusting to market needs, the experts of ELMŰ-ÉMÁSZ Group developed photovoltaic car shelters in the park for testing and gathering experience. In both cases the aim was to outline a clear design which suits the environment and to find a solution that facilitates driving in and out and reduces the possibility of damaging the vehicle body. A smaller shelter offers appropriate protection against weather effects for two cars, while a bigger shelter for up to four cars. In both cases the green energy produced by the solar panels can directly be used for charging an electric vehicle. The practical design of the footing of the larger structure enables placing, in addition to the tubes needed for draining rainwater, the inverter needed for energy production with solar cells, and even an electric car charger can be installed in it.

Key parameters of car shelter for two cars

Type of PV system	BenQ
Nominal Capacity per Panel	255 W
Number of Solar Panels	20
Installed Capacity of the system	5.1 kW
Inverter type	Growatt
Inverter Capacity	2 kW
Overall Surface of the PV System	Approx. 32 m^2
Date of Installation	11.2016

Key parameters of car shelter for four cars

Type of PV system	Solitec Solid Pro Poly 275
Nominal Capacity per Panel	275 W
Number of Solar Panels	24
Installed Capacity of the system	6.6 kW
Inverter model	Fronius Symo
Inverter Capacity	6 kW
Overall Surface of the PV System	Approx. 39 m^2
Date of Installation	02.2020

Introduction of Photovoltaic, Automatic horse feeders

Three automatic horse feeders operate in the Therapeutic Riding Centre. The electricity necessary for computer control, communication and dosage is provided by the solar panels installed on their roofs, while electricity is stored by batteries. Hence these installations can operate in island mode as well, e.g. on the pasture, where there is no electrical connection anyway.

Wind turbine

Mankind has already been making use of the wind's energy for thousands of years, at first only for sailing, later, starting in the Middle Ages, through windmills also for agriculture. Wind energy has only been used for local electricity production since the end of the 19th century, however, later this technology lost its relevance with the roll-out of the electricity grid.

Finally, in the end of the 20th century once again there was an increasing awareness of the opportunities offered by wind energy. In recent years wind is playing an important role in the rapid proliferation of renewable energy sources.

By using a generator, the wind turbine converts the rotation energy produced by its blades moved by the wind into electricity.

Most nacelles are able to make a 360 degree turn around the tower axis enabling it to operate whatever the wind direction is. For the safe operation of the generator the wind speed must remain within a given range of velocity.

Mass production of wind turbines with a capacity of only 20 - 30 kilowatts was started at the end of the 1970s in Denmark. Nowadays there are models which even have a capacity of more than 7 MW. However, the largest models are already erected in the sea, in offshore wind farms, rather than on dry land.

As it is still much simpler to erect wind turbines onshore than offshore, and as a quick connection to the already established electricity grids can easily be ensured onshore, such wind farms will continue to dominate in future developments.

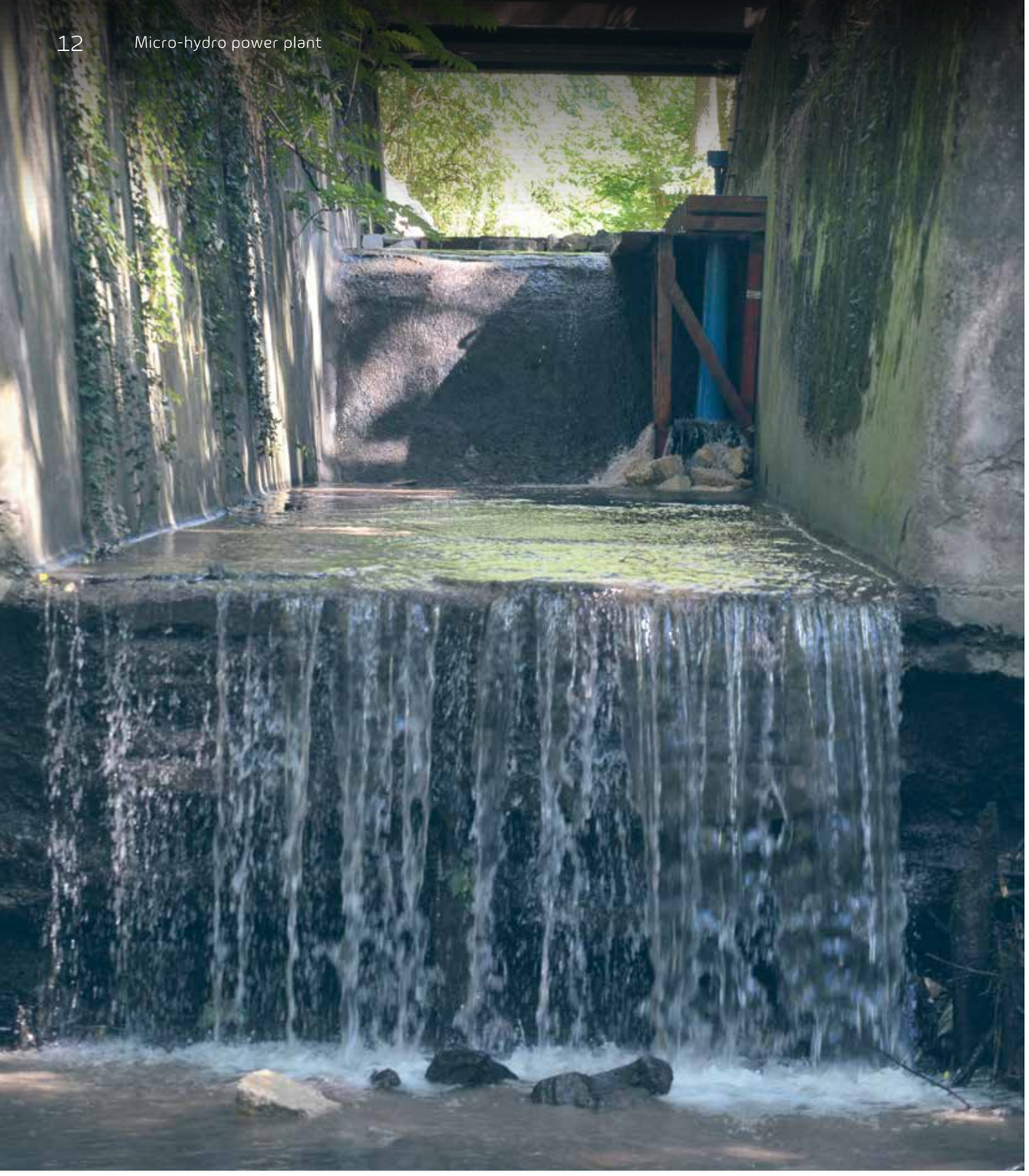
A 20 kW wind turbine feeding energy into a low voltage grid was installed in the Fót Liveable Future Park by the experts of the ELMŰ-ÉMÁSZ Group.

One of the benefits of this wind turbine type is the low start-up speed: the blades do start moving already at a wind speed of 3 m/s. The turbine has its own control unit which communicates via an optical network with the smart control system set up in the Visitors' Centre.

Key Facts of the Wind Turbine

Type	Ouyad FD12.0-20000
Nominal Power	20 kW
Nominal Voltage	360 V
Rotor Diameter	10 m
Start-up Wind Speed	3 m/s
Stall-out Wind Speed	25 m/s
Nominal Wind Speed	12 m/s
Nominal Revolution	150 rotation/minute
Generator	Permanent magnet
Blade Material	Fibreglass plastic
Tower's Height	17.4 m
Date of Installation	07. 2013

The International Children's Safety Service has installed three small wind turbines - 0.5 kW each - for research purposes.



Micro-hydro power plant

Water has already been used in history for energy generation for thousands of years. Even in the empires of the ancient world (Egypt, India, China), smaller and bigger watercourses were harnessed. From the Middle Ages use of mills (e.g. flour-mills, saw-mills) was widely spread in our region as well. Water-wheels used for these mills were the forerunners of present water turbines.

Where geographical conditions are suitable, water is one of the most efficient energy sources. Various types of hydro power stations are wide-spread, including but not limited to run-of-the-river hydroelectric power stations, pump and storage as well as tidal power stations. In this respect, water is one of the most versatile renewable energy sources.

Unfortunately, the geographical conditions in Hungary are not very favourable for the construction of hydroelectric power stations, as most of our rivers crossing the country have only a very small difference in elevation. Our major hydro power stations are located on the Tisza river (Kisköre, Tiszalök) and on Rába (Kenyeri). E.ON Hungária Group generates clean energy from its hydro power stations installed at Felsődobsza and Gibárt, on the Hernád river.

While creating the Liveable Future Park, the experts of the Group suggested that they should also harness the brook on site of the Fót facility in order to form part of the Therapeutic Riding Centre's energy system. As a result, a micro-hydroelectric power station has been built on the Mogyoród brook, and the electricity generated this way is fed into the Centre's low voltage grid. It is worth mentioning that the water intake structure, which seems quite unusual at first glance, is made of larch wood. This material is not only environmentally friendly, but also resists fungi and infections, and withstands the strain of the water and even extreme weather conditions in the long run, and because of this it is especially long-lasting. The hydroelectric plant has been installed on the Mogyoród brook, on the dams built some 100 years ago.

Key Facts of the Micro-Hydro Power Plant

Turbine Type	PowerPal Low Head MHG-200LH
Nominal Power	200 W
Voltage	220 V
Nominal Revolution of the Turbine	1500 rotation/ minute
Weight	16 kg
Height of Turbine	68 cm
Diameter of Turbine	20 cm
Generator	One-phase permanent magnetic alternating current

Heat pump

Many people are not aware that up to 80 percent of household energy consumption is used for heating and hot water production. Therefore, the utilization of natural energy sources for heating is important both for cost efficiency and environmental protection.

Heat pump offers a very simple way of ensuring ideal temperature for our homes. The equipment absorbs heat from the external environment and transfers to the place where it is necessary. Each unit of electric energy consumed can generate four units of heating energy.

Heat pumps normally use an intermediate fluid (for instance propane) for transferring heat between the heat source and the space to be heated (or cooled).

At the Fót Liveable Future Park, EL-MŰ-ÉMÁSZ Group has installed a so called air-to-water heat pump, which is connected to the heating-cooling system of the Visitors' Centre. The equipment is able to provide heating in winter and cooling in summer periods with a pipe system running under the floor. The smart monitoring system can continuously ensure an optimal temperature in the premises. As a result of the positive experiences, the International Children's Safety Service installed five additional heat pumps for the heating and ventilation of the instruction building, the stables the gymnastics therapy room and the service rooms.

The Principle of the Process is as follows:

- The working fluid, in its gaseous state, is pressurized and circulated through the system by a compressor.
- The hot vapour is cooled in a condenser (heat exchanger) until it condenses to fluid, and transfers its heat to the space to be heated.
- The condensed refrigerant, in its fluid state, passes through a pressure-lowering device while its temperature is lower.
- The refrigerant fluid then enters an evaporator where – while evaporating – it absorbs heat from the environment.
- The refrigerant then returns to the compressor, condensed, and the cycle is repeated.

Key facts about the heat pumps installed in the Liveable Future Park:

Heat Pump Type	Mitsubishi Zubadan PUHZHW140YHA
Nominal Heat Output	14 kW
Nominal Electric Output	5.21 kW
Maximum Air Carrying Capacity	6000 m3/h
Weight	148 kg
Noise Threshold	53 dB
Compressor	3-phase
Date of Installation	05.2013; 07. 2014; 10. 2017.

Electric mobility

The history of electric cars begins in the 1820s when Ányos Jedlik constructed the first electric car model at the end of the decade. After a number of other attempts, the internal combustion engines were invented in the 1910s and a new era of mass production started. This is the reason why electric vehicles were sent into a long period of dormancy.

In the second half of the 20th century the deteriorating air quality and the oil crisis aroused renewed interest in electric cars, and as a result, the first hybrid car solutions were developed in the 1980s and 1990s. During the decades that have passed since then, various electric propulsions have been further improved.

Electric Propulsion Types:

- Hybrid (petrol-electric or diesel-electric),
- Plug-in Hybrid (chargeable from the grid as well),
- Hybrid with Range Extender (electric car with its own internal combustion engine),
- Purely Electric Propulsion.

E.ON Hungária Group has been committed to environment-friendly technologies and clean energy for a long time. That is why the utility launched its Electric Mobility (e-Mobility) Programme. As a result of this programme, e-cars were added to the company fleet and public electric car charging stations are installed nationwide. Today lots of electric car chargers are available in Hungary, thus the country can easily be crossed with an electric car. In addition, the Group has been working in cooperation with a number of partner companies to popularize electric transport.

Benefits of Electric Cars:

- local greenhouse gas emission is zero,
- less noise pollution,
- lower costs for maintenance and operation,
- reduced rates for registration tax, road tax, company car tax,
- these cars can even be used in the event of a smog alert,
- parking benefits.

On the premises of the Fót Liveable Future Park ELMŰ-ÉMÁSZ Group has installed a free-standing electric car charger station, a wall charger and various new chargers types for car shelters. This way up to six e-cars' batteries can be charged simultaneously with the smart pole. In one of the footings of the car shelter at the office building a unique e-car charger obtained from Nissan was installed that can be used not only for charging the battery of a car, but can also feed the energy stored in the car back into the grid.

In technical literature this technology is called V2G (Vehicle-to-Grid). By testing and using this technology the energy management system used in the park can be upgraded, and the capacity of the battery of an electric car connected to the charger can also be used, in addition to the existing central storage equipment.

The 62 kWh battery pack of a Nissan Leaf connected to this V2G charger almost doubles the battery storage capacity permanently installed in the park to help that a higher share of the locally produced renewable energy can be stored within the park. With this solution it created, first in Hungary, the possibility of "live" testing of V2G that can in the future confirm the viability of this technology. Should a larger number of V2G chargers be installed (at least a few hundred), the connected e-cars can act as virtual power plants to enhance the stability of the electricity grid. Should a lower number of these equipment be installed (a few ten), they can locally contribute to integrating to the grid renewable energy based generation. Both the visitors of the Park and the Group's staff are encouraged by the chargers to choose an environment-friendly transport mode when travelling to Fót.

Key Facts of the free-standing Car Charger Station:

Type	RWE Easy Station
Number of simultaneously chargeable cars	2
Charger Station Capacity	2 x 22 kW
Nominal Current Rate	2 x 3 x 32 A
Charging Time	Depends on the model and the cable, Approx. 1.5 - 6 hours
Connector Type	Type2

Key Facts of the Wall Charger Station:

Type	RWE Easy Box
Number of simultaneously chargeable cars	1
Charger Station Capacity	11 kW
Nominal Current Rate	3 x 16 A
Charging Time	Depends on the model and the cable, Approx. 1.5 - 6 hours
Connector Type	Type2

Key Facts of the Eluminocity Charger:

Type	EBEE Wallbox
Number of simultaneously chargeable cars	1
Charger Station Capacity	22 kW
Nominal Current Rate	3 x 32 A
Charging Time	Depends on the model and the cable, Approx. 1.5 - 6 hours
Connector Type	Type2

Key Facts of the Smart Pole Charger:

Type	EBEE Wallbox
Number of simultaneously chargeable cars	1
Charger Station Capacity	22 kW
Nominal Current Rate	3 x 32 A
Charging Time	Depends on the model and the cable, Approx. 1.5 - 6 hours
Connector Type	Type2

Key Facts of the Vehicle to Grid Charger:

Type	EBEE Wallbox
Number of simultaneously chargeable cars	1
Charger Station Capacity	22 kW
Nominal Current Rate	3 x 32 A
Charging Time	Depends on the model and the cable, Approx. 1.5 - 6 hours
Connector Type	Type2

Key Facts about the Electric Bicycle Charger:

Type	In-house development by ELMŰ
Number of simultaneously connectable vehicles	4
Charger Station Capacity	4x1.4 kW (total 5.6 kW)
Charging Time	Depends on the model, 0.5 – 3 hours
Connector Type	IPS4 Schuko (230VAC)
Approx. 1.5 - 6 hours	CHAdeMO
Connector Type	Type2

An electric scooter and bicycle charger prototype developed by ELMŰ's professionals is also available in the park. The equipment is suitable for simultaneously charging up to four vehicles with 230 VAC chargers supplied by the manufacturer. The charger is equipped with individual protection that outputs voltage to the connectors only over the period while the consumer plugged in is consuming power from the grid. This way, when the vehicle battery is fully charged or charging is interrupted by pulling out the plug, the connector will immediately be de-energised. Charging can be started with a pushbutton, the current status is indicated by a colour LED ring around the pushbutton. When a defective, faulted equipment is connected, the software-controlled overcurrent protection or the integrated cutout immediately switches off. Due to the electric bicycles and scooters available in the park it is the best imaginable site for testing the prototype: this way the bicycle charger can be upgraded under controlled circumstances, with continuous usage.

Energy storage and recovery system

One of the key tasks and major challenges of electricity generation based on renewable sources is to create the possibility for energy storage and recovery. The installation of energy storage equipment can ensure that fluctuating energy generation due to weather conditions and varying load on the grid can be balanced, and that electricity demand can be met at any time.

Energy consumption fluctuates both on a daily and on an annual level. Higher and lower energy demand periods are called peak and off-peak hours. In peak periods it might be necessary to ramp up a fast-responding power station (e.g. a gas turbine or a pump and storage power plant) or to increase its generation.

On the low voltage grids – like the one in the Therapeutic Riding Centre at Fót – the best means of balancing fluctuating energy supply is a high efficiency battery storage. The battery is charged during the low demand periods with locally produced renewable energy, which can be immediately fed back to the grid whenever it is necessary. The local energy storage equipment largely contributes to the energy autonomy of the facility as the energy generated does not have to be consumed immediately. Depending on the actual demand it can either be used as an energy source or an energy sink/energy buffer.

The state-of-the-art energy storage and recovery system installed by ELMŰ-ÉMÁSZ Group professionals at the Fót Liveable Future Park ensures the most efficient utilization of locally generated energy. The system is permanently connected to the grid and is able to store such electricity for a certain period of time in batteries or feed it back to the electricity grid based on a predefined schedule or responding to a single command, minimizing by that the losses on transmission.

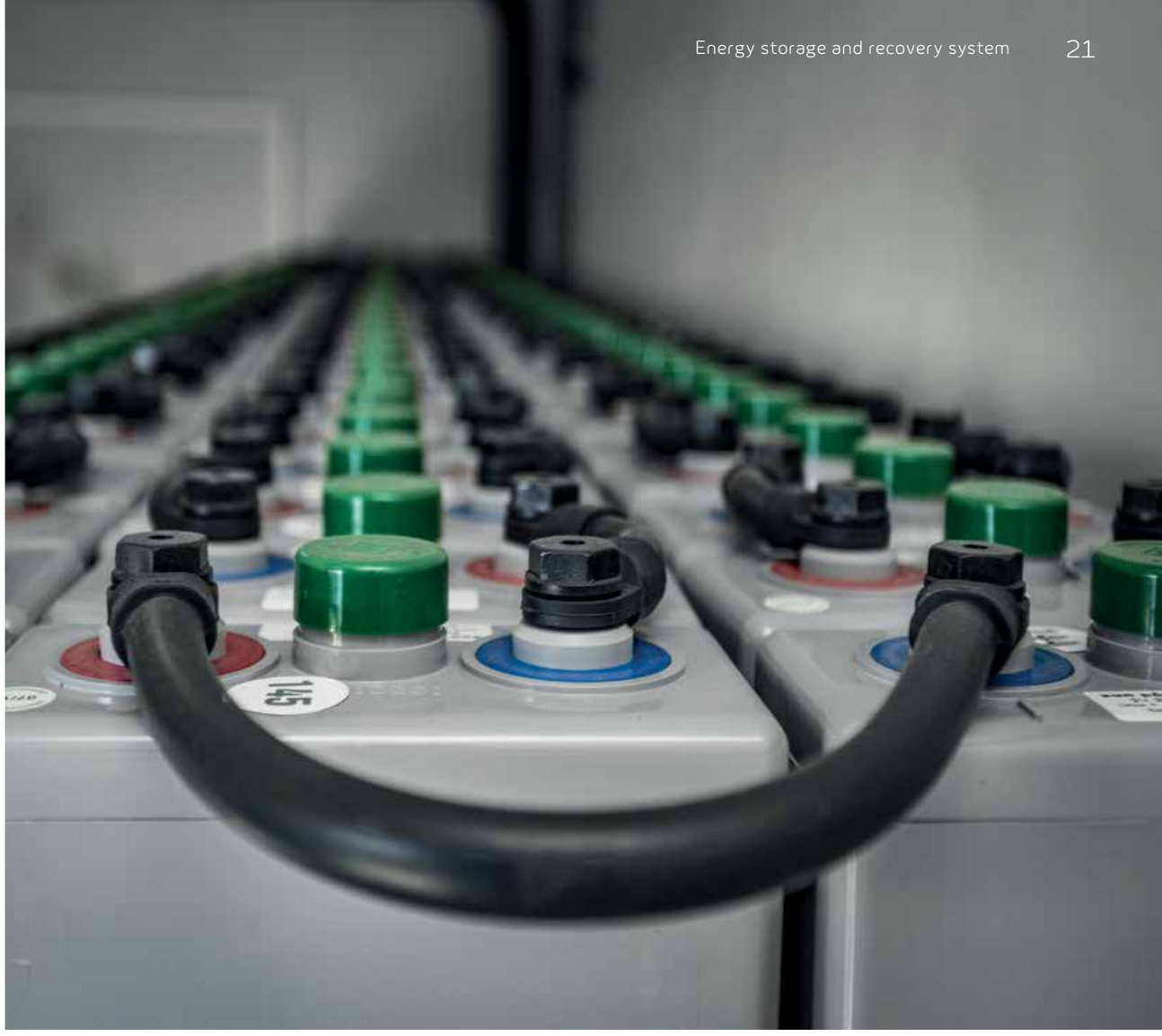
Components of the System:

- battery charger (rectifier),
- battery storage,
- inverter,
- metering, control, and command system.

Key Facts about the Energy Storage and Recovery System:

Type	PowerQuattro FHUPQ 20 kVA
Nominal Power	20 kVA
Nominal Capacity	40 kWh
Network Connection	3-phase, synchronised with the grid
Battery Type	Hoppecke 4OPzV solar Power 250
Number of Batteries	336
Nominal Voltage	372 V
Operating Temperature	-20 °C - +50 °C
Life Time	1600 cycles when usual discharge is 80%
Date of Installation	05.2015

By using the experiences gained during the installation of the state-of-the-art storage and recovery system, the experts of ELMŰ-ÉMÁSZ Group installed a new residential-size energy storage system in the battery premises. The operation of this system is similar to the system introduced earlier with the exception that to this system photovoltaic cells placed on the roof or in the garden can be connected directly. The system is destined for storing the energy generated in households with solar panels, then transmit it to the household when needed (e.g. in the morning and in the evening). In case the batteries are fully charged, the system feeds electricity back to the grid, and in case of its failure it is still capable of serving the most important consumers as uninterruptible power source (maximum 1 kW).



Key Facts about household-size Energy Storage and Recovery System

Type	PowerQuattro FHUPQ_ 20 - VIN
Nominal Power	3 kVA
Nominal Capacity	5 kWh
Network Connection	1-phase, synchronised with the grid
Battery Type	Sun.power VRM 12V58
Number of Batteries	8
Nominal Voltage	96 V
UPS output	1 kVA
Life Time	1600 cycles when usual discharge is 80%
Date of Installation	03. 2017

Outdoor Lighting Storage

Following the Smart City concepts, the experts of ELMŰ-ÉMÁSZ Group developed a new type of energy storage system. With the help of this equipment low-powered devices (such as cameras or 3G/4G WiFi routers, etc.) which need a 24-hour supply can be connected to the outdoor lighting network. When the outdoor lighting system is switched off, energy supply is ensured by the built-in batteries of the equipment. The system also provides information concerning the power input of the consumers, the battery status, and any occurring failures in the system.

Key Facts of the Street Light Storage

Battery	24 V/14.5 Ah, Li-ion
Camera	Hikvision IP camera
Life Time	3200 cycles when usual discharge is 80%
Date of Installation	11. 2016

Smart Street Lighting and Photovoltaic Park Lights

Outdoor lighting was introduced in cities well before electricity was discovered. With the appearance of electricity, it has been developed and modernised continuously ever since. This development continues to this day. Moreover, due to the dynamic development of LED technology and the introduction of smart devices, the outdoor lighting system is currently going through a significant transformation. 14 percent of the energy consumption of the European Union is used for lighting, and the amount of greenhouse gas emitted this way equals three-quarters of motor vehicle pollution. Outdoor lighting is only a part of this but surely there is a significant transformation taking place right now in this field.

The aim of ELMŰ-ÉMÁSZ Group was to present the widest possible range of LED park lights available in the Hungarian market to those interested. Connected to the renewable energy project started in the Fót Liveable Future Park, five different energy-saving LED park lights and four types of island operation photovoltaic LED park lights were installed.

The remote monitoring of the luminaires was realised with a Prolan Eclipse monitor system; this way by controlling the luminaires in night hours – but at the same time ensuring the necessary amount of light – significant energy saving can be achieved. The remote monitoring system ensures the individual controllability of the luminaires as well as the two-way communication link. This solution also enables us to quickly detect grid defects and other failures concerning the lights.

The experts of the Group installed two movement tracking outdoor lighting systems from the entrance to the park up to the office for the luminaires along the road. The goal was, in addition to energy saving, to gather direct experience with the installation and operation of various systems. One of the key elements of operating the system is the movement detector/radar placed on lamp poles. These detectors can measure the speed and the size of an object passing by the given pole. In the function of this measurement it can turn on, in the direction of the movement, the total brightness of one luminaire when a pedestrian is passing, while two luminaires when a larger and faster object is passing. After the object has passed, the luminaires are regulated with a delay back to the preset minimum brightness. In practice it looks like a light wave passing along the lamps that keeps pace with the moving object. With appropriate settings very significant energy saving can be achieved because lighting is switched on only when it is actually justified. Experience shows that this solution pays back the fastest in streets with low traffic. The above solution can also reduce the light pollution of cities and roads.

A common feature of all systems is that they have metering, so the operator can have precise data about the amount of electricity consumed.

Parts of the control and monitoring system:

- Light control
- Circuit control
- Central unit

Parts of the movement tracking system:

- Movement detecting sensor
- Light control
- Circuit control
- Central unit

Until then, the ELMŰ-ÉMÁSZ Group had no direct experiences regarding photovoltaic and battery LED outdoor lighting devices. Hence on the site of the Fót Renewable Energy Park three photovoltaic LED lights were installed in order to light the playground. Lights from three different manufacturers were installed so the experts of E.ON Hungária Group obtain plenty of experiences. Outdoor lighting at one of the roads has also been provided by photovoltaic, battery-operated LED lights.

No construction of public grid is necessary for these lights, therefore it was possible to avoid digging up the whole site. Based on the favourable experiences, the staff persons of ELMŰ-ÉMÁSZ Group installed three more photovoltaic LED lights along the road.

Key Facts of Photovoltaic LED Lights:

- No feeding from the grid is necessary
- In case of intense sunlight batteries charge in 3-4 hours
- Scattered light is enough for charging the batteries
- Lighting can be provided for several days with only one charging
- It automatically switches on when it is getting dark

Key Features of Smart Outdoor Lighting Installed in the Park:

Monitoring System	Prolan (Eclipse)
Luminaires	17 pc LED
Photovoltaic lights	6 pc LED
Date of Installation	11.2016

Key Features of Hofeka Movement Tracking Outdoor Lighting:

Monitoring System	Hofeka (Tvilight)
Luminaires	11 pc LED
Date of Installation	11.2018

Key Features of Prolan Movement Tracking Outdoor Lighting:

Monitoring System	Prolan (Eclipse)
Luminaires	7 pc LED
Date of Installation	11.2019

Smart Outdoor Lighting Pole (Smart Service Point)

In cities, along with the spreading of smart devices and electric cars, more and more poles are installed on public places. This can be disturbing in a densely populated city centre, for instance in Budapest around Oktogon. Recognising this, the experts of ELMŰ-ÉMÁSZ Group started developing a multifunctional outdoor lighting pole. This pole integrates IT devices and energy solutions involved in the Smart City concept. On the site of the Fót Renewable Energy Park a street version and a park version of the smart lighting pole were installed. Since IT devices are also very fast developing, currently the second generation pole with numerous new functions is available in the park.

In summer 2018, the Group installed a smart outdoor lighting pole group consisting of five units in Lechner Ödön fasor, in the 9th district of Budapest.

The street version is a 7 in 1 lighting pole including the following functions:

- Up-to-date, controllable LED outdoor lighting
- Electric car charger
- LED display
- Surveillance camera
- Environmental sensors
- Emergency button
- LED light indicating UV radiation

Lighting Pole:

- ELMŰ-ÉMÁSZ Group – Hofeka joint development
- 8 m high pole
- Clear design that includes also the camera holding console
- An electric car charger is also built in the pole

Outdoor lighting:

- Hofeka Tweet (130 W) LED road lighting luminaire

Electric car charger:

- One car at a time can be charged 24 hours a day
- Maximum charging capacity 22 kW (3x32 A)
- Type2 connector – standard in public places
- Smart charging through SCADA system

LED display:

- LED display clearly visible in daylight too
- 128 x 256 pixel resolution
- Content changed via remote control

Camera:

- Pelco 360-degree camera
- 20x optical zoom
- SCADA connection through PLC (Power Line Communication)

Wifi:

- Approximately 100 m access around the pole
- Free of charge, no password needed
- T-systems 4G internet access

Environmental sensor:

- Sensors developed in Hungary (Boreas)
- UV-B sensor
- Air pollution measurement
- LED signal
- SCADA connection

Other:

- Emergency button
- RFID identification for e-car charging

Park version lighting pole including the following functions:

- Up-to-date, controllable LED park lighting
- 2 Schuko connectors for electric bicycles, and for laptop charging
- 2 USB sockets
- Surveillance camera
- Wifi access
- UV-B signal
- Bench
- Bicycle rack

Lighting Pole:

- ELMŰ-ÉMÁSZ Group – Hofeka joint development
- 4 m high pole
- Clear design
- 2 connectors were built in the pole
- A bench fixed to the pole, fitting for 4 persons
- Bicycle rack fixed to the pole, fitting for 4 bicycles

Outdoor lighting:

- Hofeka Gloria (36 W) LED park lighting luminaire

Electric connectors:

- Two bicycles, laptops can be charged simultaneously
- Maximum of 3 A charging capacity through the two USB connectors
- Controllable regular connector

Camera:

- Sunell FullHD camera
- SCADA connection

Wifi:

- Approximately 100 m access around the pole
- Free of charge, no password needed
- 4G internet access

UV-B sensor:

- LED signal
- SCADA connection

Smart control system

In order to provide for a safe energy supply, electricity operators do apply metering, data collection, management, and supervisory control systems using computer-controlled devices. The server and computers used by the Chidren's Safety Service have been provided by Hewlett-Packard Enterprise.

Key Tasks of the Smart Control System:

- Monitoring the energy consumption,
- Remote control, remote operation,
- Developing special schedules and routines,
- Forecasting energy demand,
- Optimisation of the entire system (increasing efficiency, reducing transmission losses and costs).

Energy management systems are based on SCADA (Supervisory Control And Data Acquisition) systems. Special software applications (supplementary modules) make these systems "smart".

The software applications run on a high capacity computer system provided by HP Magyarország Kft. supporting the initiative of the Children's Safety Service and E.ON Hungária Group. Microsoft also contributed with its software products to the operation of the energy management system.

All data of the energy-generating equipment operated at the Therapeutic Riding Centre and key end-user data is stored in the "brain" of the system, on a central server. It provides for processing and displaying the data, commands are issued from here, and archives data with a 10-second resolution.

The operation of the facilities using renewable energy sources at the Fót Liveable Future Park largely depends on the weather conditions and on energy demand at a given time. This means that careful planning was required in order to integrate each and every element and component into a network and develop the smart control system. This present system is managing over 600 different data which provide various information from the entire territory of the park.

Experiences gained during the operation of the energy management system of the Fót Liveable Future Park – e.g. grid integration of renewable energies – are key elements for the development and roll-out of the future smart grids of E.ON Hungária Group.

Key System Parameters:

- Citect SCADA software,
- Smart metering equipment,
- Smart modules using Cicode programme language:
  - Battery control
  - Smart e-car charger control
  - Temperature regulation in the Visitors' Centre
  - Display and control of sprinkler pump tank level
  - Display of UV-B radiation level
- Graphical user interface,
- Client connection,
- Remote access,
- Report generating programme,
- Interface for web access.

The living laboratory: research and development at the liveable future park

Based on the research cooperation agreement concluded with the Budapest University of Technology and Economics and Óbuda University, a joint research is being conducted focusing on the renewable energy installations operated in the Fót Centre, and in particular on the optimal coordination of these installations during operation. The research committee established for this objective defines the annual research programmes with priorities changing from time to time. The Park serves as a living laboratory for university students, PhD candidates, researchers, and for the employees of E.ON Hungária Group. Several fully equipped workstations are available in the Visitors' Centre, where, amongst others, the following questions are being studied:

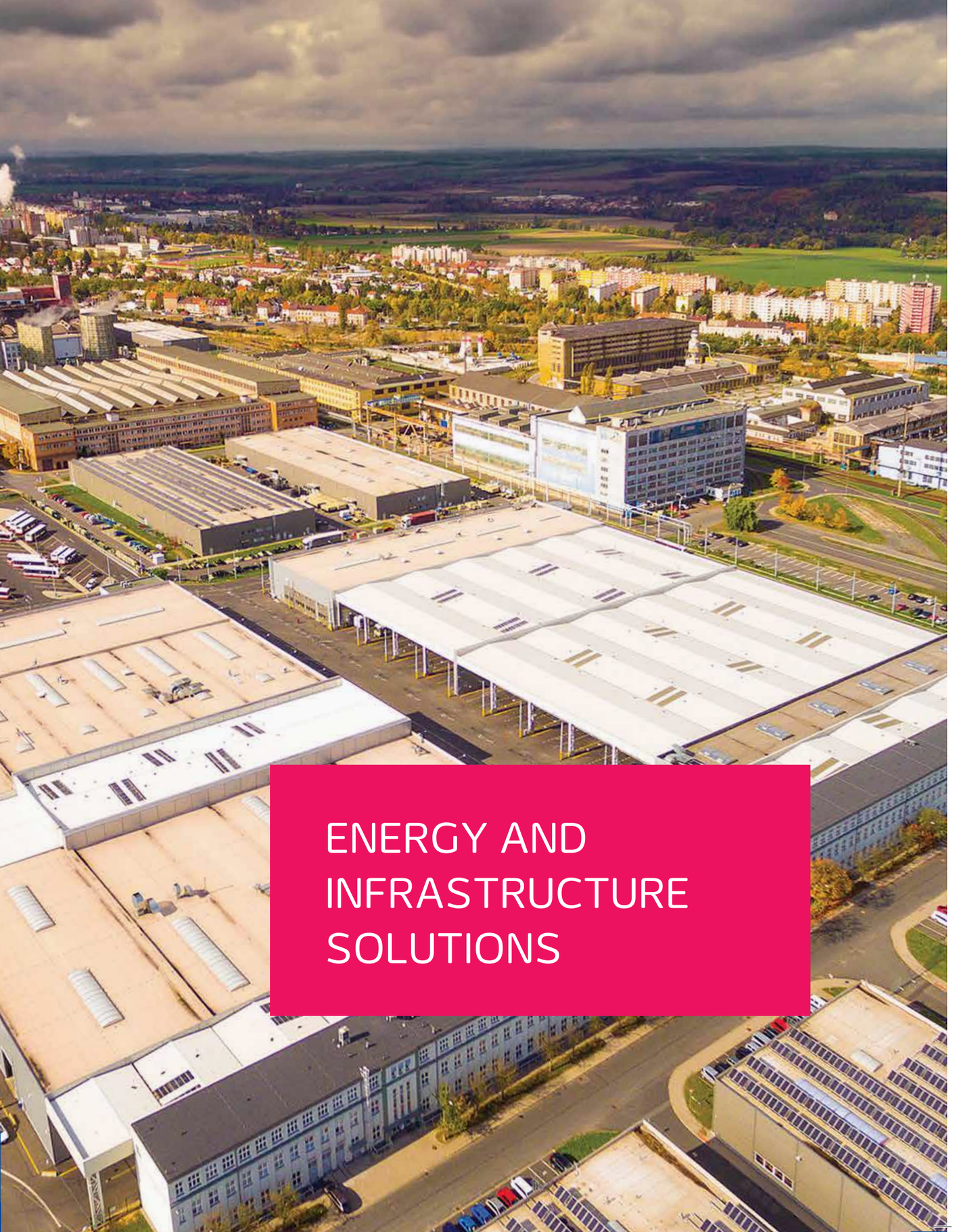
- What are the requirements for the electric grid of the future?
- How can renewable energies be increasingly integrated into the grid, taking reliable energy supply and grid stability into account?
- How can the smart metering system be further improved?
- Which energy storage technologies are most suitable for network integration of renewable energies?
- How can the storage installations be used in an optimal way and how can they be improved?
- How can batteries of electric vehicles be used for storing energy?
- What methods can be applied for forecasting electricity generation by renewable resources?
- With what methods and how can energy consumption be efficiently influenced?

The opportunities lying in the park were realised not only by universities, but also by the technical fields responsible for strategic planning and operation of E.ON Hungária Group's distribution network. Several measurement, research projects are currently in progress in the park that are seeking solutions for special operating statuses, phenomena that occur in the network. The data measured and documented here in real circumstances can contribute to enabling the service providers initiate amendments in legislation. Thanks to the cooperation with the universities, 21 scientific studies and degree thesis have been elaborated by spring 2020.

Measurements important for the distribution system operator (DSO):

- Earthing resistance measurement,
- Soil resistance measurements at several depths,
- Cable temperature measurement in soil,
- Temperature measurement under the asphalt at several depths.

As we can see, in addition to the fulfilment of its primary objective, the Park also contributes actively to the development of new procedures, concepts, and products and therefore paves the way for future energy solutions.



ENERGY AND INFRASTRUCTURE SOLUTIONS

Green energy for a clean future

While during the past decades energy for the end-users was mainly generated by huge power stations, decentralised units which produce electricity locally have recently become increasingly important.

At the Fót Therapeutic Riding Centre of the International Children's Safety Service heating, air conditioning, lighting required to the therapy, training and conferences is provided by an independent energy island.

By realising the optimal interaction of power generation, metering, and control units an almost autonomous system has been created that is largely independent from big power plants and the public electricity grid. This way the public electricity grid only serves as a backup solution when there are unfavourable weather conditions. Moreover, the system provides for the opportunity of selling surplus electricity produced during favourable weather conditions.

Perhaps you, too, have already raised the question how this kind of energy autonomy can be achieved in your own home or in any other property.

Whether you intend to implement an innovative, smart energetics concept in your home or at a site similar in size to the Therapeutic Riding Centre, we are ready to provide you with advice and support regarding the:

- Efficient usage of energy,
- Development of a comprehensive energy concept,
- Selection of the equipment or equipment type that suits the particular location best (e.g. solar energy systems, heat pumps),
- Elaboration and implementation of turn-key customised, decentralised energy generation solutions,
- Implementation of supplementary energetics solutions,
- Development of energy autonomous systems.

This offer primarily focuses on households and small businesses.

Our Group is continuously working towards smart green energy concepts, solutions, and products of the future. Please do not hesitate to contact us!

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