REKK
FOUNDATION FOR REGIONAL POLICY CO-OPERATION IN ENERGY AND INFRASTRUCTURE

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# Country Paper:
# Energy Research, Development and Innovation in Hungary

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The REKK Foundation for Regional Policy Co-operation in Energy and Infrastructure is a Budapest Based think tank. The goal of the REKK Foundation is to contribute to the formation of sustainable energy systems in Central Europe, both from a business and environmental perspective. Its mission statement is to provide a platform for open-ended, European-wide dialogue between government and business actors, infrastructure operators, energy producers and traders, regulators and consumers, professional journalists and other interested private entities. The Foundation develops policy briefs and issue papers with forward-looking proposals concerning challenges posed by energy and infrastructure systems and organize regional forums allowing stakeholders to become familiar with the latest technological and regulatory developments within the industry.

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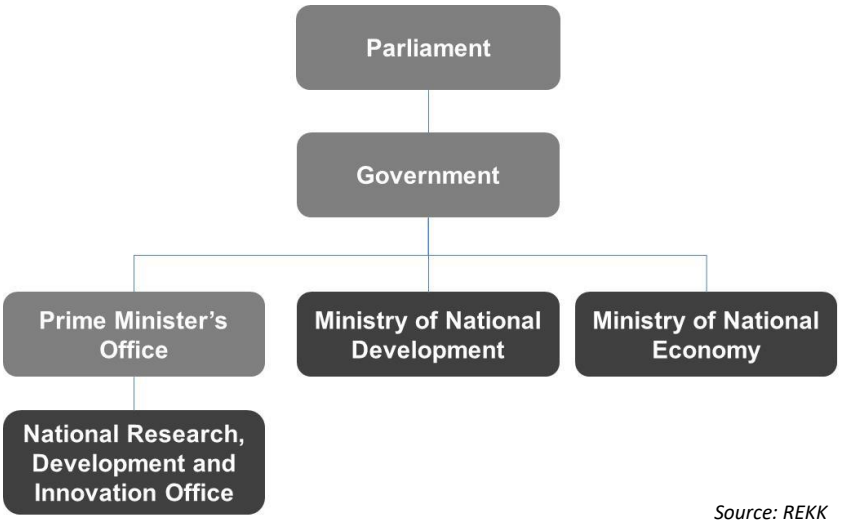
# Hungary's policy towards energy innovation

The RDI in energy sector covers a wide range of areas in Hungary. The innovative business model of the virtual power plants, the energy container project of Eon, the energy storage pilot of Alteo and the electric car manufacturing plant of AUDI will result that the climate-friendly alternatives of traditional energy services spread across the country.

According to the country report of IEA, in 2012[1] the country spent 86 million euros on energy related Research, Development and Demonstration[2], which accounted for 0.08% of GDP. The IEA median spending in the same year was 0.04%. Hungarian expenditures were two times this value, which was the fourth largest ratio among IEA countries after Luxemburg, Finland and Norway. However, the IEA was not able to provide newer information on spending due to the lack of available data. In the following years the Hungarian Central Statistical Office reported some aggregated data on RDI spending, but it is not possible to identify from those the strictly energy related expenses. The measurement of energy innovation is a major challenge.

*1. Figure: Institutions responsible for energy related RDI policy in Hungary*




*Source: REKK*

The R&D and innovation policy in this area is determined by three major institutions. The *Ministry of National Development* is the main owner of energy policy; it is responsible for traditional energy sources,

[1] IEA (2017): Energy Policies of IEA Countries: Hungary 2017 Review

[2] In terms of this paper we use the following definitions:
**Research** is the process of creating ideas, processes, technologies, services or techniques that are new to the world. In terms of input, available statistics often refer to Research & Development (R&D) spending.
**Innovatio**n is here defined as introducing something new to a given organisation—but not necessarily new to the world. For innovation to be beneficial, it must be useful
and valuable, and can often be monetised.
Source: Jacques Delors Institute: Making the Energy Transition a European Success, 2017

renewable energy and climate policy. The *Ministry of National Economy* is the leading institution in the decarbonisation of transportation and co-operates in setting the energy efficiency targets.

The RDI law of 2014[3] created the National Research, Development and Innovation Office (NRDI Office) to take over the role of several smaller R&D institutions. The NRDI Office handles the unified *National Research, Development and Innovation Fund (NRDI Fund)* "to provide state support for research, development and innovation and can be used solely for this purpose"[4]. According to the law the NFDI fund is separated state fund and its mission is to "develop RDI policy and ensure that Hungary adequately invest in RDI by funding excellent research and supporting innovation to increase competitiveness"[5]. The NRDI Office is also responsible for Horizon2020 planning and it started to work on January 1st 2015.

The financial budget of energy related public RDI spending is mainly determined by the size of the funds handled by these three institutions as well. The NRDI Fund was about EUR 247 million (HUF 74.1 billion) in 2015[6], but this contains the public support for all the eight priority areas, out of which energy is only one – however priority – area. The funds available for energy RDI from the Operative Programmes – as laid down in the strategic documents of the two ministries – are even higher. According to IEA, Hungary received a total of EUR 2126 million from the Structural Funds to support R&D and Innovation between 2007 and 2013, and EUR 2149 million for the period 2014-20. Again, this is overall RDI public support, not only energy related (which is 86 million euros in 2012).

The strategic goals of the Hungarian Government in energy RDI are enacted in the following key legislation and documents:

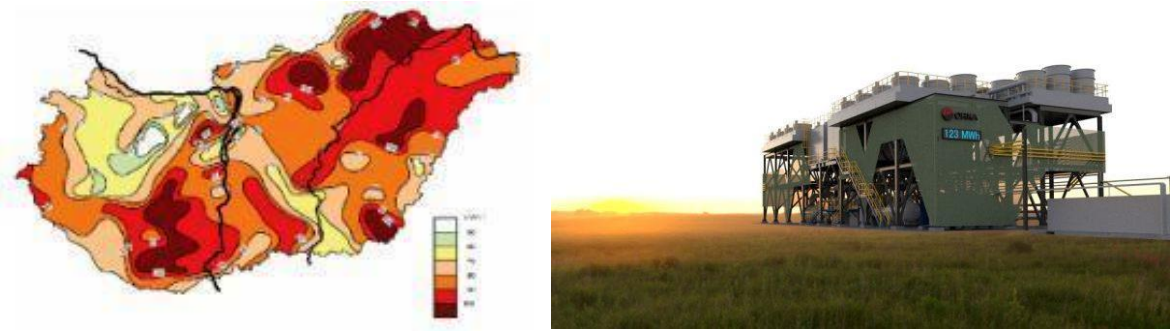
- EU Structural Funds Operative Programmes (2014-2020): The main OPs financing energy RDI are: Economic Development and Innovation Operative Programme (GINOP) and the Competitive Central Hungary Operational Programme (VEKOP). For example, under the GINOP "clean and renewable energies" priority several calls have been published for corporate RDI activities.
- Alternative Fuel Action Plan[7]: The document contains different scenarios for different vehicle growth cases, and defines the required infrastructure development plans.
- Energy & Industrial Development and RDI Action Plan (currently under open consultation): The action plan is not yet accepted, but it can serve as basis for the future governmental plans in Hungary. The plan highlights several key RDI fields which are: nuclear energy, renewable energy and other alternative technologies, fossil energy, energy transportation and storage technologies, smart systems, industrial energy efficiency and emission reduction, energy efficiency of buildings and transportation with alternative fuels.

[3] The Act about scientific research, development and innovation 2014/LXXVI
[4] Source: NRID Office website
[5] Source: NRID Office website
[6] IEA (2017): Energy Policies of IEA Countries: Hungary 2017 Review
[7] Ministry of National Development (NFM): The policy program determined by the directive on the installation of alternative fuel infrastructure elements, , 2016

- National Energy Strategy 2030 (accepted in 2011): This document targets a 9% share of electric and hydrogen fuelled vehicles in road and rail transport by 2030.
- Jedlik Ányos E-Mobility Action Plan: The complex e-mobility strategy contains the deployment plan for refuelling stations, pilot projects, metering & settlement.
- National Nuclear Research Program: This program has been approved by the Government in 2015[8] and ensures EUR 6.2 million (1920 million HUF) from the NFDI fund for nuclear research projects. The leader of the research program is the Hungarian Academy of Sciences, and the main element of the program is developing up-to-date modelling techniques for the numerous processes of nuclear power plant operation.

One of the potential policy successes in energy related research and development in Hungary is related to the huge geothermal potential which creates an opportunity not just for geothermal heating, but electricity production as well.

*2. Figure: The exceptionally favorable geothermal resources of Hungary and Turawell, the first geothermal electricity power plant in central Europe*




*Source: GeoSEE and KS Orka*

Geothermal heat projects are common in the country; however there were several attempts to develop a technology, which is able to provide electricity from geothermal energy in an economically viable way. In mid-2016 construction works started to build a small size (2.6 MW) power plant in Tura by KS Orka (Singapore) and Mannvit (Iceland), which is the first geothermal electricity power plant in central Europe. The Turawell geothermal power plant has just started the commissioning phase on the 7th September 2017 and official opening is planned in November 2017. The power plant is a combined heat and power plant, with 3 MW electricity and 7 MWth heating capacity. Turawell is using the 129 Celsius water coming from underground and would ensure electricity for 800 families during the whole year.[9]

[8] Government Decree 1284/2015. (IV.30.)
[9] http://www.portfolio.hu/short/kozep-europaban-is-kulonleges-eromuvet-adtak-at-magyarorszagon.261645.html

## Priority policy focus: boosting up e-mobility

The Hungarian Parliament pays special attention to the electrification of transport in the National Energy Strategy 2030, accepted in 2011. This document targets a 9% share of electric and hydrogen fuelled vehicles in road and rail transport by 2030. Reaching the goal with only electric vehicles would imply the appearance of close to 400 thousand EVs on the roads in the forthcoming 13 years, resulting in a 0.65-0.8 TWh yearly additional demand for electricity. The government also accepted a complex e-mobility strategy, named "Jedlik Ányos Action Plan" in 2015, and decided on a deployment strategy for refuelling stations, pilot projects, metering & settlement (Government Decision 1487/2015). In 2016, the government introduced further support measures to enhance the deployment of e-vehicles: providing exemptions from congestion charge, setting a 30% alternative fuelled passenger vehicle share target for the fleets of governmental organizations by 2030, and a program for light vehicles (Government Decision 1027/2016).

Benefits related to green licence plates are regulated by different pieces of legislation. Besides full electric vehicles, green licence plates can be acquired by owners of plug-in hybrid, and range extended electric vehicles, that can run at least 25 and 50 kilometres on electricity, respectively. The owners of these cars are exempted by regulation from the car registration tax, annual circulation tax and company car tax, as well as the duty payable at the transfer of vehicle ownership. The municipalities of several cities offer free parking to drivers with green licence plates, and in some of the cities (including Budapest) they are given privileged access to otherwise restricted areas (e.g. the Castle District in Budapest). The national government encourages the purchase of full electric vehicles by providing a grant covering 21 percent of their purchase price, up to a maximum HUF 1.5 million. Besides private users, governmental and municipal institutions and companies can also have access to the subsidy, where for companies there is an upper limit on purchasing: a maximum of 35 electric vehicles per entity.

Hungary transposed into national law the main elements of the EU legislative framework on charging infrastructure based on the Alternative Fuel Directive in a governmental decree in June 2017.[10] The decree defines the major elements of the legal framework for charging, however, some issues are still under discussion. There are several competing concepts on the most appropriate business model of publicly available charging infrastructure operation. The sharing of tasks and responsibilities between the infrastructure service provider and the e-mobility service provider, the desirable level of interoperability between the competing charging infrastructure operators, and some commercial issues related to home charging and public charging stations still need to be clarified.

To facilitate the deployment of the charging infrastructure, municipalities of towns having at least 15,000 inhabitants could apply for financial support to set up public charging points, with as much as 100% support intensity. Also, the government have recently implemented a tender related to the installation of 150 additional charging stations to be built in large cities, touristic regions, near motorways and close to central and local government offices.

[10] 170/2017. (VI. 29.)

The 2016 amendment of the Government Decree 253/1997 about 'the National Settlement Planning and Construction Requirements' prescribes that in new car parking lots and parking areas of larger commodity stores at least 10 out of 100 parking stalls have to be equipped with wire conduits for accommodating charging point outlets, in two years. In case of existing parking lots, at least 2 stalls out of 100 must be installed with charging points.

Innovation related to electric mobility and autonomous vehicles will be backed by a new auto industry test track to be built in Hungary (Zalaegerszeg) on a 250-hectare area by the end of 2019. The test track will offer services to car manufacturers and provide the opportunity of collaboration with educational and research institutions.

*3. Figure: Test track for self-driving cars in Michigan – The Hungarian test track will be built by 2018 from 40 billion HUF state support*[11]

As regards vehicle production, AUDI will start producing electric cars in its Hungarian plant located in Győr, and cooperates in innovation projects with Hungarian research institutions and universities, such as the Hungarian Academy of Sciences, the Budapest University of Technology and Economics and the Széchenyi István University of Győr. Electric buses are produced by the Chinese BYD in Komárom, while the Modulo Medio Electric, an electric bus developed in Hungary by Evopro Ltd, is assembled by MABI-BUS Ltd. The real-life operation of 20 electric Modulo buses are currently tested on the streets of Budapest.

According to the Hungarian Electromobility Association, presently 170 public charging stations operate in Hungary, and 3200 green licence plates have been issued to electric cars, out of which about 600 vehicles are full electric. It is visible from the above-mentioned policies, that the government places a huge effort on the support of electric vehicles. It is important to note, that the 600 full electric vehicle in place shows that the penetration of EVs are not overwhelming, so probably there is room for further improvement in the current polices.

[11] http://blog21.hu/2016/05/19/40-milliardos-tesztpalya-epul-zalaegerszegen-videokkal/

Concluding the above, we see that the policy measures regarding the e-mobility are quite successful in Hungary. The number of electric or hybrid vehicles is increasing, as the number of charging stations do so, too. There are debates ongoing about the criteria for receiving green licence: as currently not only full electric vehicles are eligible but also those cars, which can travel 25 km on electricity, it results cars with generally high fuel consumption and high emission of air pollutants get green plates, too. Besides, the number of charging points seems to lag behind schedule. The Jedlik Ányos Action Plan highlights that until 2020 approximately 3000 public charging point should be in place in Hungary in order to consider electric vehicles as a real alternative. Since the publication of the action plan in 2015 the number of public charging points increased from 60 to 170, thus the current rate of expansion is insufficient to reach the 2020 goals. The government should provide a framework in which it is possible for private companies to install and operate public charging stations in a profitable way. One important step toward forming this framework was the 170/2017. (VI. 29.) Government Decree, but further measures are needed.

# Energy innovation in companies' strategies

The private sector plays a significant role in initiating R&D actions as well. Despite the rule of thumb saying that out of 10 R&D project only 1 is successful, there are numerous corporate initiatives to find new, more climate-friendly or cost-efficient solutions instead of traditional ones. The following examples have been launched recently by two main players of the energy sector: Alteo, a Hungarian power producer and EON Hungary, the Hungarian subsidiary of EOn.

## E.ON Energy Container

The innovative solution is able to serve the energy needs of customers, both household and small industry, at remote locations, without being linked to the grid. The E.ON Energy Container is “an islanded (off-grid) PV and storage-based (battery + water-hydrogen-based closed system fuel cell) generation unit packed in a container”[12]. The container uses the sunlight to produce energy through the PV panels, and stores the energy surplus in batteries if there’s any. When the batteries are fully charged, the remaining energy is stored in hydrogen cylinders in the form of hydrogen gas[13]. Hydrogen storage is an adequate option for long-term energy storage (seasonal shifting, capacity provision for the low PV generation timespan), therefore complements the battery system to provide greater security of supply. The system is fully independent from the grid but still offers reliable power service for customers.

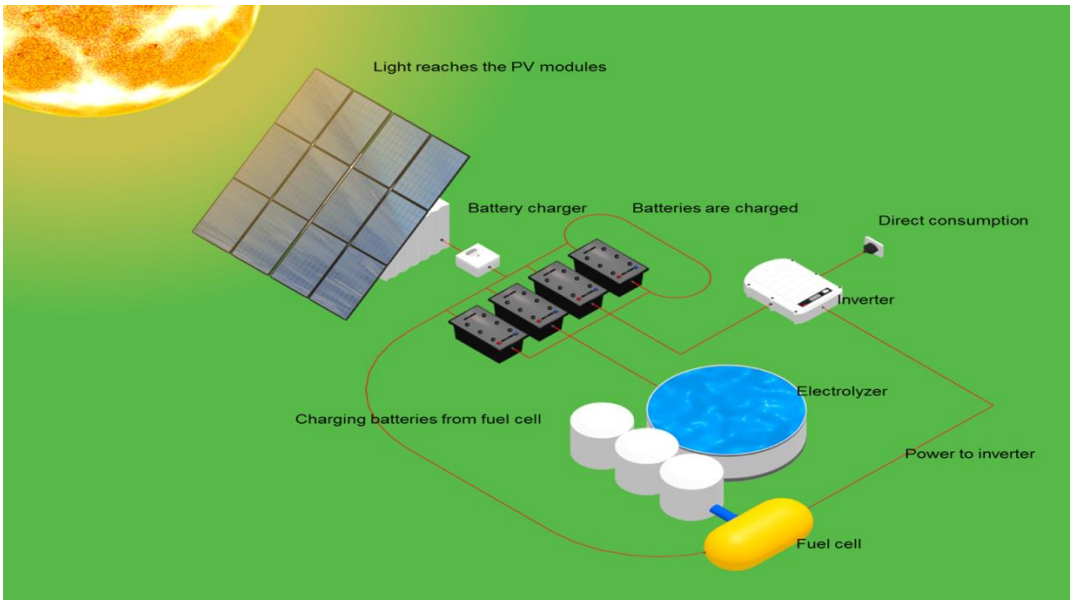
The system characteristics are the following[14]:

- The electric power is produced by PV panels independently from the grid. The system is able to supply 3x16A and 4000-6000 kWh/year.

[12] E.ON Hálózat: E.ON Energy Container
[13] Futher information: https://www.youtube.com/watch?v=q76fp0M80k0
[14] E.ON Hálozat: E.ON Energy Container

- Surveillance and communication through internet
- Island mode, operation range: -20 … +40°C outside temperature
- Fast commissioning, installation and relocation

*4. Figure: The shematic model of E.ON Energy Container*




*Source: E.ON*

According to the one-year test operation of the pilot container in Bátaszék (Gemenc Forest) the container has fulfilled all the specified goals. Since 10th November 2015 the energy container of the forester house in Gemenc has produced 7000 kWh energy, and avoided the emission of 3114 kg carbon-dioxide[15].

## Alteo Energy Storage Solution

ALTEO Group, a Hungarian power producer and supplier that focuses on renewably energy and smart energy management services, has launched a 3.5 mEUR R&D project to create an intelligent power storage system based on battery technology. The project, co-financed by Hungary's National Research, Development and Innovation Agency, will aim at integrating wind turbines with a storage facility at the company's dispatching center that controls production from its small units of combined heat and power. The development will not only allow for optimizing production and supply at the company's level, but will also have positive system-wide effects.

[15] http://www.h2energycontainer.com/hu/

Pumped storage power plants, which account for 95% of grid connected storage capacity in Europe, can only be constructed in locations that provide suitable geological features and society's willingness to accept them. In Hungary, for instance, according to the Ministry of National Development suitable locations are all nature protection areas, therefore this solution is out of question.

Moreover, while pumped storage systems can also quickly react to imbalances within the electricity network, the integration of renewable energy sources is better facilitated by a larger number of smaller, decentralised storage facilities, such as the one planned by ALTEO Group. The central element of the project will be a Li-Br battery of approx. 2 MW, with a maximum energy charge of 2 MWh. The battery will be integrated into a dispatching center that will be able to not only efficiently regulate the production of two connected wind power plants, but also to offer ancillary services to the transmission system operator (TSO). Later, power-based heat production will also be integrated into the system.

R&D activities to be carried out in the framework of the investment will seek answers to questions related to the deployment, system integration, and operation of battery-based power-storage. The company promises to share its experience with potential future investors and the Hungarian TSO. Based on all the information and data to be gained from the project, future installations may be designed to operate much closer to their technical optimum, which means greater efficiency and a contribution to maintaining stable, well-balanced electricity systems capable to integrate more and more renewable production.

Apart from the wind power plants and the battery, the upgraded dispatching center will also contain 7 gas-fired smaller sized power plants. Such a design will allow for an accurate and fast regulation of production, making the center a good candidate to earn revenues on the primary reserve market. Another pillar of the future business model will be the smoothing out of renewable production: as the risk of wind power plants not producing energy at all because of the lack of wind is high, the minimization of the cost of balancing energy is an important consideration.

Special attention will be given to the effects that the developed business model and its optimal operating strategy have on the life-cycle of the technology. Currently, there is a great variety of often contradictory information on how the various charging practices such as state and length of charge, depth of discharge, or external temperature affect the life-cycle of batteries.

Working out the optimization algorithm of the business model is a key, and finding the right balance between the revenues from the primary reserve services and the revenues from the dispatching center activity will be a continuous challenge. Success, however, may encourage other market players as well to find market based revenues from their renewable production instead of or parallel to RES subsidies.

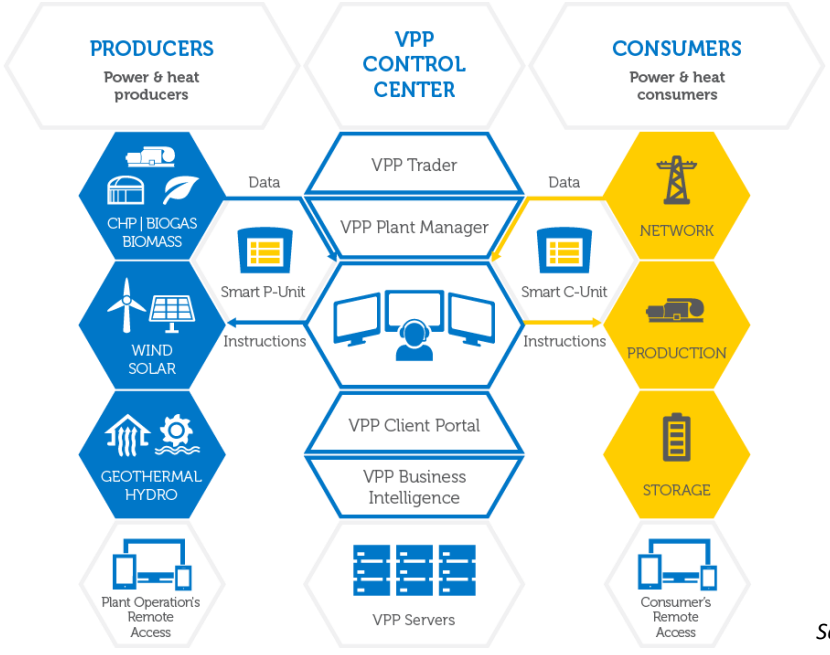
# Success stories

## Impacts of changing regulatory environment – forced innovation in the Hungarian small-scale gas fired electricity production (VPPs)

The virtual power plants (VPPs) are good example of the forced innovation on the electricity market. The built-in capacity of the small scale (below 50 megawatt) gas-fired turbines and engines increased up to 1500 MW between 2004 and 2008 because of a generous state subsidy program which offered similar benefits for the combined heat and power (CHP) producers as to the renewable generators through a feed-in tariff mechanism. The government realized the strong tariff pressure on the end-user prices of the quickly growing capacity of the CHPs and decided a tariff reduction for the new gas-based investments in 2008. Although the governmental action has stopped new investments, the 1.5 GW units realized by that time already caused serious pressure on electricity tariffs. As a result of this, the government radically changed the subsidization mechanism of combined heat and power in 2011. The new regulation terminated the guaranteed feed in tariffs for the small-scale gas fired CHP producers.

The termination of the guaranteed feed-in sales opportunity caused a big shock within the small-scale CHP industry. The owners of the close to 1500 megawatt built-in capacities faced with deteriorating market conditions and had to find new opportunities to increase their income on the competitive market segments. However, some companies realized not only the serious problems of the decreasing profitability, but also discovered the new opportunity of market consolidation. These integrators partially owned a fleet of small-scale production units but also elaborated cooperation agreement with individual independent producers to *integrate their balancing capabilities into a commonly operated virtual power plant (VPP)*.

*5. Figure: The technical setup of virtual power plants in Hungary*




*Source: VPP Energy Zrt*

The VPP operators invested into a sophisticated information-technology system to control the common production of the virtual fleet and sold the balancing capabilities on the balancing market. The balancing electricity market offers good commercial opportunities for the owners of the CHPs because of the limited supply and the high prices of balancing energy. VPPs have several advantages against of the inflexible large-scale competitors, because of their small-step flexibility. Thanks to the tender rules and processes implemented by the Hungarian TSO (MAVIR), the virtual power plants successfully won the tenders for balancing power and achieved close to 100 MW balancing power in 2016 on monthly average.

For 2016 eight VPP operators were active on the balancing market and offered virtual fleet services including Alteo, E.ON, Veolia, Greenergy, Alpiq, MVM, VPP and Ploop. The overall capacity of the integrated units achieved close to 600 MW of small-scale CHPs. Although the additional income from the balancing market seems not enough to achieve a high profit rate for new investors, it can help the existing units to survive in the competitive power production market.

## Key EU-funded projects

The evolution of the VPP innovative business model was driven by market player's revenue-seeking strategy. The financial sources from EU Structural and Cohesion Funds, Horizon 2020, Connecting Europe Facility, ERDF, IPA and InnovFin have multiplier effect on the number of RDI projects and fruitful innovations. The following projects are good examples of successful co-financing.

### PAN-LNG project

The Hungarian Gas Transport Cluster Association (MGKKE) developed the PANNON-LNG project in which 5 LNG gas stations and a small scale pilot liquefaction plant will be built in Hungary. The project is co-financed by the European Union (Connecting Europe Facility) up to the 85% of the project cost. The total amount of the support is 14.435.796 Euro[16]. Currently, one LNG filling station is under construction, another 4 are expected to be built next year.

The significance of the project lays in its contribution to the decarbonisation of the European freight transport. The project is to prepare the infrastructure required for the development of LNG-based transport and to physically install the first filling points and ensure the supply thereof[17]. The security of energy supply in Hungary (and Europe) would be improved by LNG-based transport due to reducing crude oil based fuel dependence. Furthermore, the vehicles with gas-based fuel have significantly less pollutant emissions and consume less energy compared to oil-based vehicles. Compared to other alternative energy sources, LNG has favourable sustainability indicators. As Hungary has a remarkable role in European transit, three TEN-T corridors could be served by LNG-based trucks and buses.

[16] ec.europa.eu, European Commission, PAN-LNG Project. Date: 2017.11.16. Link: https://ec.europa.eu/inea/sites/inea/files/fiche_2014-hu-tmc-0629-m_final.pdf

[17] panlng.eu, PAN-LNG Project. Date: 2017.11.16. Link: http://www.panlng.eu/english/the-project/

The primary consumers of the LNG-network are heavy duty vehicles. Since the stations of the PAN-LNG project will be the first LNG stations in Hungary, it is important to create consumer demand as well. Co-partners of the project already include vehicle importers, moreover, IVECO, Scania and Volvo have already announced that in 2018 LNG-fuelled tractors will be launched, and the development and production of LNG-fuelled buses have also started by Pannon and Ikarus Global.

Besides the PANNON-LNG project for heavy duty vehicles, the Clean Fuel Box (CFB) project has also been launched by MGKKE to enhance the decarbonisation of transportation sector further. The essence of this project is the distribution of fuel from LNG stations to retail sale, using CNG stations. CFB Project has also 85% co-financing from the CEF (9,872,835 Euro), for which the MGKKE undertook the construction of 39 CNG filling stations and put in operation a fleet of 50 vehicles. In Hungary CNG-based public transport has been relatively widespread, for example in Miskolc city 75 CNG buses were put into circulation in 2016.

### 3SMART[18]

The Smart Building – Smart Grid – Smart City (3Smart) is a significant regional innovation initiative, with the participation of project partners from Hungary, Croatia, Slovenia, Austria and Bosnia-Hercegovina. The main objective of the 3Smart project is "to provide a technological and legislative setup for cross-spanning energy management of buildings, grids and major city infrastructures in the Danube Region". The project partners include 3 major Hungarian partners: the University of Debrecen, the E.ON Tiszántúli Áramhálózati Zrt. and the Hungarian Energy and Public Utility Regulatory Authority (HEA). The project will develop a software tool for optimizing energy management of buildings and the exchange between grid and building through exchanging energy and prices data.

The budget of the 3Smart project overall is EUR 3,79 million, out of which ERDF Contribution is EUR 2,68 million, whereas the IPA Contribution is EUR 0,5 million.

The project outputs are the following:

i.) Modular software tool for energy management on building and distribution grid side,
ii.) Five pilot actions in different Danube Region countries including buildings and grids with intersected technology/regulatory setups and
iii.) Strategy to enable city-wide energy management and related regulatory barriers removal in the Danube Region.

The "major innovative moment is in vertical two-way synchronization through all the modules of the energy management tool via simple interfaces to attain optimal operation of the buildings and the grid, and easy modules add-on to the existing already deployed automation equipment". The favourable

[18] Project co-funded by European Union funds (ERDF, IPA) (DTP1-502-3.2-3Smart);
Project webpage: www.interreg-danube.eu/3smart

results of the project are expected to encourage the installation of distributed storages, which would improve energy security in the region.

# Lessons learned

The Hungarian energy related research, development and innovation activities are based on corporate initiatives and strategy up to a large extent. The examples of the Virtual Power Plants and the EON container show that careful technical planning and endurance lead to innovative new solutions which can be successfully sold at market price.

The national and European RDI funds play a significant role in encouraging energy innovation further besides the corporate initiatives. The PAN-LNG project assists the substitution of diesel-fuelled trucks by more climate-friendly fuels, and the energy storage R&D pilot's results will lead to better integration of intermittent plants into the grid.

The regulatory background ensures possibility for all the different areas of the energy innovation; however the Hungarian Government decided to lay emphasis on the support of the decarbonisation and electrification of the transportation sector. The related goals of the National Energy Plan and the Jedlik Ányos Action Plan will accelerate the substitution of hybrid and electric cars for gasoline vehicles.

# Outlook

In Hungary, the RDI spending is above the IEA average, and several projects have been launched in energy production (both electricity and heating), and in decarbonisation of transportation sector as well. Still, there are new challenges that the following policy proposals could answer.

## Policy proposals

1) The examples in this study show that most of the successful case studies come from the private sector initiatives with certain level of support from central RDI funding, where direct involvement of research institutions and universities were limited, with the exception being the Audi electric vehicle development, where three Universities are involved. Having limited budgetary resources in Hungary, maintaining the leading role of private companies in energy related RDI is an efficient solution due to the capital intensity of most development. Transparent rules connected with competitive distributing of the limited public resources (e.g. through tendering schemes) would further enhance budgetary RDI spending.
2) Even for the Hungarian Government it is difficult to obtain information about the energy related RDI spending. This issue comes from two directions. First, the methodology of research, development and innovation measurement is complicated, and because of the fast technological changes, might be updated regularly (i.e. energy related RDI indicator could contain only gas and power statistics). The other cause of this is the relatively large number of projects and potential

support funds. The setting up of the NRDI Office has improved the situation, and the Energy & Industrial Development and RDI Action Plan also highlights, that the creation of a new information platform is necessary. The database of R&D projects could be enhanced i) by updating the statistical methodology and by ii) ensuring that all relevant projects are listed. It is important to highlight however, that this policy measure will only be effective, if the dataset will contain information which is in one way or other useful for the market players, (otherwise it would become just an additional bureaucratic burden for the market participants). This underlines the importance of the stakeholder involvement already in designing the database and the data collection process.

3) The large part of the energy consumption comes from the public sector. Thus, the public institutions are in a good position to test and introduce energy innovation results, especially in case of energy efficiency solutions (measurement, grid management etc).
4) The financing costs of R&D and the risk of low demand discourage energy market players from new research. The commitment from government side to enhance future demand might decrease this risk. The role of public orders in the pre-commercial phase might become relevant.
5) As the Hungarian economy is highly dependent on the performance of automotive sector, the government should monitor carefully the major trends of the industry. The e-mobility and the autonomous vehicles offer good R&D opportunities for Hungarian investors to participate in the disruptive innovations of the sector. We welcome the decision of the government to invest into an autonomous test infrastructure and suggest analysing further actions to make this test filed more attractive to private companies.
6) The ambitious planned increase of electric vehicles requires well-functioning charging infrastructure. We think that market companies have all capabilities to invest into and operate the electric charging stations. However, some cases investment subsidies can accelerate the deployment. We suggest the government to elaborate a transparent program of subsidies. We believe that a tender for investment subsidies would be an effective way of allocation of the non-refundable subsidies.
7) The cooperation of the gas fired CHPs shows a good example of forced innovation when the changes of the regulatory environment indicated a successful adaptation of the companies. As a result of investment into innovative software-based solutions to integrate the production of small-scale CHPs, the virtual power plant operators acquired special skills and capabilities which can be extended to other fields of the changing electricity sector. We think, that the technologies developed by VPPs could be used effectively in the integration process of consumers and RES producers into a more flexible electricity system. We suggest the legislative bodies to create the legal conditions of participation of aggregators on more fields of balancing and ancillary services.
8) International experience shows, that one of the most efficient support to geothermal projects would be to provide risk insurance for developing new wells, and further risk sharing support might lead to projects in new fields.
9) As the 18% of households are served by district heating in Hungary, and there are lot of new building blocks under construction, the new procedures, innovative business solutions that

enable the integration of RES heat producers could have positive effect on decarbonisation of heating sector.

10) Corporate level innovation requires predictable institutional environment including laws, governmental policies and actions. We suggest the establishment and operation of a working group or consultative forum of public and private stakeholders to discuss the prerequisites of a supportive innovative framework.
11) Even though there are several available RDI funds, and numerous support programs exists, these programs sometimes run parallel and the different supporting schemes are not harmonised for energy market participants. Availability of information could be enhanced (both national and European funding possibilities).
12) The new Energy & Industrial Development and RDI Action Plan could serve as a good basis for the research, development and innovation policy planning. The priorities at the different energy sector fields should be determined based on the goals of the National Energy Strategy.
13) The RDI goal setting criteria in the integrated national energy and climate plans defined by the European Commission should be in line with the national priorities.