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Innovation on Urban Energy

Technology Report

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Address Vienna Business Agency. A service offered by the City of Vienna.
Mariahilfer Straße 20
1070 Vienna, Austria
Phone +43 1 40 00-86 70
Fax +43 1 40 00-86 720
E-mail info@wirtschaftsagentur.at
Web viennabusinessagency.at

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Introduction

Dear Readers,

The worldwide energy supply is currently undergoing a radical change. The challenge of gradually phasing out the use of fossil fuels as well as strongly influential trends such as the decentralisation of (renewable) energy production, urbanisation and digitalisation are driving forces of this structural transformation. In this process of change, particular importance is placed on cities, as energy supply in urban areas is crucial to reducing greenhouse gas emissions and achieving the climate protection goals set out in the Paris Climate Agreement. Urban areas currently account for around 70 percent of global CO_2 emissions. Technology and innovation represent key elements in shaping the future of energy, which can provide great opportunities for the business sector, too. The next few years will decide which technologies, strategies and business models will be successful in global competition. Many collaborations on both regional and local levels have proven that good ideas can be transferred globally.

In 2017, the Vienna Business Agency dedicated a series of events on urban energy innovation dealing with crucial aspects of the future of energy, such as the prospects for digitalisation in the energy sector, buildings and energy storage, new innovative energy products and services, financing issues and the role of start-ups and entrepreneurs in providing impetus for the energy revolution. In addition to market developments and trends, participants, speakers and stakeholders from various industries and sectors discussed business examples, project ideas and framework conditions for the future of the City of Vienna.

The transformation of energy production is associated with both numerous challenges and great opportunities, which can also be utilised in the context of Vienna as an innovation-driven location. This technology report sheds light on some of the key thematic areas and their diverse constellation of players.

The team at the Vienna Business Agency

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Europäische Union Investitionen in Wachstum & Beschäftigung. Österreich.

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1 Shaping the energy system of the future

1.1 The common challenge of climate change

Climate change is one of the greatest challenges in the history of humanity. The influence of human activity on rising global temperatures in the last few centuries is evident. This is due to the emission of greenhouse gases such as carbon dioxide (CO2), methane, nitrous oxide and other gases which absorb the long-wave infrared radiation reflected off the earth's surface. This greenhouse effect – in principle a natural process - is greatly intensified by human activity such as the burning of large amounts of fossil fuels. Since the beginning of industrialisation and especially since the middle of the 20th century, the concentration of CO2 in the atmosphere has been rising sharply. While before industrialisation the atmospheric concentration hovered around 280ppm, in 2016 it exceeded the critical level of 400ppm.

Increasing risks of climate change

The impacts associated with climate change are already clearly noticeable and will become more marked if a quick turnaround cannot be achieved with regard to greenhouse gas emissions. Together with at times disastrous weather events in many parts of the world, the very hot summer in Europe in 2017 has also shown that increasing climate-related risks are leading to direct consequences for people, animals, agriculture, forestry and many other sectors. Significantly more heatwaves, water shortages, increased incidence of droughts, forest fires and extreme weather events such as storms etc. describe the risk related to climate change.

According to the World Meteorological Organization (WMO), temperatures in the year 2016 had already reached 1.1°C above pre-industrial levels.1 In Europe, 2016 was the third-warmest year since measurements began and followed close behind the record-breaking years of 2014 and 2015. In parts of Austria, extremely dry conditions led to considerable crop losses. Climate change is also associated with high risks and consequential damages to Austria's national economy, from agriculture and forestry (crop losses, forest dieback) and tourism (lack of snow) to the energy economy (lower yield from hydropower, damage to infrastructure). An economic study conducted for Austria (Cost of Inaction – COIN), demonstrates that climate-related damage costs will increase by 2050, compared to today and reach an average annual level up to € 8.8 billion, especially if global emissions are not reduced significantly.[2]

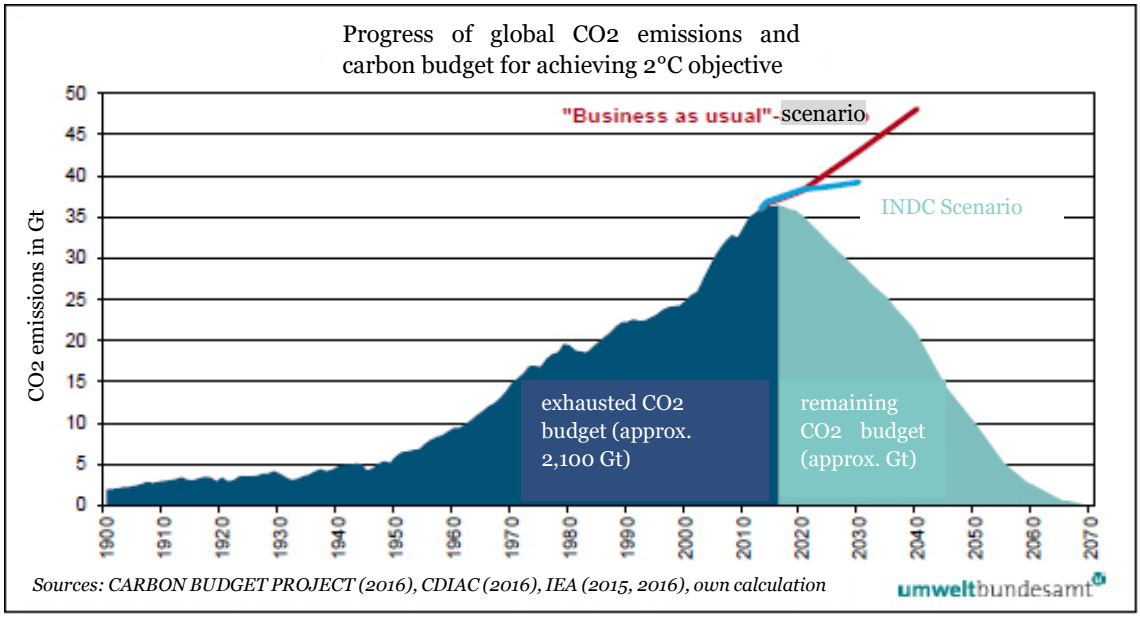
The Paris Climate Agreement as a milestone

The UN Climate Agreement, signed in Paris by 195 countries on December 12th, 2015 and entered into force on November 4th, 2016, is a historic step in international climate protection and environmental policy. Signatories are committed to the objective of limiting the global temperature increase to well below 2 degrees Celsius and pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. In order to achieve this goal, greenhouse gas neutrality - a balance between greenhouse gas emitted by human activity and that absorbed by carbon sinks (e.g. forests, seas) - needs to be achieved on a global level within the second half of this century. This ultimately goes hand in hand with decarbonisation, the systematic and complete cessation of burning fossil fuels (coal, oil, natural gas).

Industrial nations, which are responsible for the highest share of cumulative greenhouse gas emissions, must move forward. Rapid action must be taken in view of the limited remaining "Carbon budget" for limiting the global temperature increase to +1.5 and +2°C. The longer the delay in reducing greenhouse gas emissions, the less time will remain in which to effect this reduction. With a current annual figure of around 40 gigatonnes (Gt) of global emissions, the Carbon budget associated with the 1.5° goal would be depleted in approx. 15 years.[3] Taking into account Austria´s share of emissions, a study by the Wegener Center shows that a national carbon budget would be exhausted in, at best, less than 20 years if current emission levels remain unchanged.[4]

1 World Meteorological Organisation: WMO Statement on the State of the Global Climate in 2016. Geneva 2017
2 K. Steininger, M.König, B.Bednar-Friedl, L. Kranzl, W. Loibl, F. Prettenthaler, (Hg.); Economic Evaluation of Climate Change Impacts: Development of a Cross-Sectoral Framework and Results for Austria, Springer, 2015
3 C. Le Quéré, G. Peters et al. Global carbon budget 2017. www.globalcarbonproject.org
4 L. Meyer, K. Steininger: Das Treibhausgas-Budget für Österreich. Wegener Center Wissenschaftlicher Bericht 72-2017.

Graph: Carbon budget for achieving the 2° goal – rapid emission reduction necessary[5]



Adherence to climate protection obligations introduces a far-reaching structural change of energy supply, and with it the foundation for many industrial processes, services and lifestyles. This is both a challenge and an opportunity for new technologies and innovation.

1.2 Austria's obligations within the EU

The European Union (EU) has set long-term objectives of reducing greenhouse gas emissions by 80 to 95 percent (in comparison to 1990) by 2050 and increasing both energy efficiency and the proportion of renewable energy sources in overall energy consumption. The Climate and Energy Package 2020 and the framework for a climate and energy policy up to 2030 represent intermediate steps in achieving structural change towards a low carbon economy by 2050. As part of the Climate and Energy Package, the EU has prescribed a legally binding objective of reducing greenhouse gas emissions by 20 percent, in comparison to 1990, by the year 2020. Furthermore, an agreement was made to increase energy efficiency by 20 percent from the "business as usual" scenario.

As part of these obligations, Austria must reduce greenhouse gas emissions from sources not covered by the EU Emissions Trading Scheme (ETS) by 16 percent, in comparison to 2005 (record level of emissions), by 2020. For companies within the ETS, an EU-wide reduction goal of 21 percent was defined. The share of renewable energy sources in gross final energy consumption in Austria must be increased to 34 percent by 2020 (currently at around 33 percent). The Energy Efficiency Act, enacted by the Austrian Parliament in 2014 to implement guidelines for energy efficiency, makes provisions for the stabilisation of final energy consumption at 1,050 petajoules (PJ) by 2020.

Interim step 2030

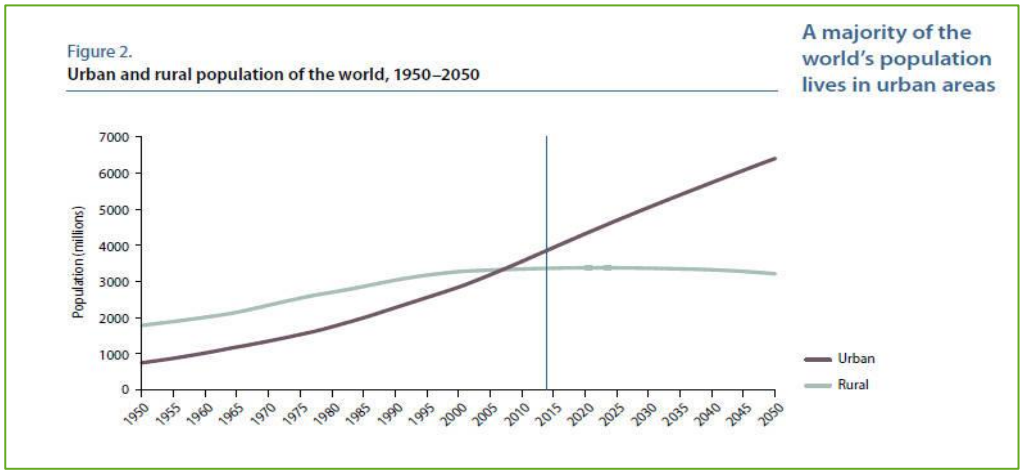
Ahead of the UN Climate Conference in Paris in 2015, the European Union set binding objectives for the year 2030, including reducing greenhouse gas emissions by at least 40 percent from 1990 levels, increasing the share of renewable energy sources by at least 27 percent and increasing energy efficiency by at least 27 percent. The European Commission published a proposal for mandatory national yearly objectives which would obligate member states to reach their goals in sectors not covered by the Emissions Trading Scheme by 2030, as part of a European "effort sharing" system. A 36% reduction of greenhouse gas emissions from 2005 levels is foreseen for Austria.

5 Umweltbundesamt: Klimaschutzbericht 2017. Vienna, 2017

1.3 Cities as engines for change

Since 2009, more than half of the world's population has lived in urban areas. The continuing trend towards urbanisation is indisputable. While the urban proportion of the population was still at 30 percent in 1950, it is now at 54 percent. An increase to 60 percent is expected for 2030 and in the year 2050, it is estimated that 66 percent of the world's population will be living in urban areas.[6] In terms of climate protection, the crucial questions are how this urbanisation will take place, which spatial structures are to be created and how energy supply will be organised.

Graphic: Urbanisation as a global phenomenon (UN World Urbanization Prospects, The 2014 Revision)



In recent years, cities have become significant players on the international climate protection stage. This is due to the innovative capacity of cities as well as their involvement. 90 percent of urban areas are placed in coastal regions, where the rising sea level as well as the frequency of hurricanes are becoming an increasing threat. As studies show, the organisation of urban infrastructure has a significant impact on the balance of emissions. Variations in the structures built may affect long-term emissions by a factor of 10. On the one hand, this is effected by the energy consumption of the buildings themselves, and on the other hand, by spatial structures designed to facilitate short distances and both public and eco-friendly transport. In addition to this, the way that cities are designed has a very long-term effect on emissions.[7] Lock-in effects by carbon-intensive infrastructure such as new fossil fuel power plants or road infrastructure – have consequences that last for decades. This is why the next few years will be crucial to emission levels right through to the middle of this century. Urban investments worth 375 billion US dollars worldwide will be required between now and the year 2020 in order to adjust the infrastructures of the city towards the 1.5° goal.

Best practice: Cooperation in focus

A major driving force of urban energy innovations is the great number of initiatives and platforms that have arisen in recent years for the sharing of best practice models, learning from the experiences of others and increasing implementation of these models. Examples include the C40 initiative, ICLEI (Local Governments for Sustainability), numerous Smart Cities initiatives, the Compact of Mayors and the Covenant of Mayors and many more.

The advantage of these networks is that cities across the world face very similar challenges such as strong population growth, infrastructure deficits, ecological problems, threatening gridlock, etc. This is also the case for many solutions, whether in mobility, new energy supply systems or IT applications: in the energy sector, successful models spread rapidly. Cities allow for efficient supply with technical (mobility, energy, water, etc.) as well as social (education, health, etc.) infrastructure, products and services, and they are the starting point for vibrant economic activity and innovation.

[6] UN-Department of Economic and Social Affairs "World Urbanization Prospects." The 2014 Revision
[7] Shobhakar Dhkal: We can cut emissions in half by 2040 if we build smarter cities
https://theconversation.com/we-can-cut-emissions-in-half-by-2040-if-we-build-smarter-cities-67499

1.4 Climate protection and the Smart City goals of the City of Vienna

Climate protection has been a central issue in Vienna since long before the Paris Climate Agreement. As early as the end of the 1990s, the first climate protection programme (KliP I), a substantial foundation for concrete measures, was created. This programme was adapted and continued by the KliP II in 2009, and will be further developed and expanded until 2020. It comprises 37 programmes of areas with a total of 385 individual measures across a range of activities: energy generation, energy use, mobility and urban structure, procurement/waste management/agriculture and forestry/conservation, and public relations. The implementation of these planned measures will result in reductions of 1.4 million tonnes of greenhouse gas emissions each year from 2009 to 2020.[8] In 2006, the Urban Energy Efficiency Programme (SEP) was also adopted by the Vienna City Council. Its objective was to create a strategic framework for energy efficiency measures in Vienna by 2015. The forecast rise of energy consumption in Vienna was to be reduced from +12 to +7 percent. This goal was exceeded by far, as shown in an evaluation report on the period from 2006 to 2015. A follow-up programme in line with the new European objectives and framework conditions is currently in development.

Smart City goals
The Smart City Wien framework strategy provides an essential point of reference for the future of energy supply. The following quantitative goals, adopted by the Vienna City Council on the 25th of June 2014, are the main focus of the strategy:[9]

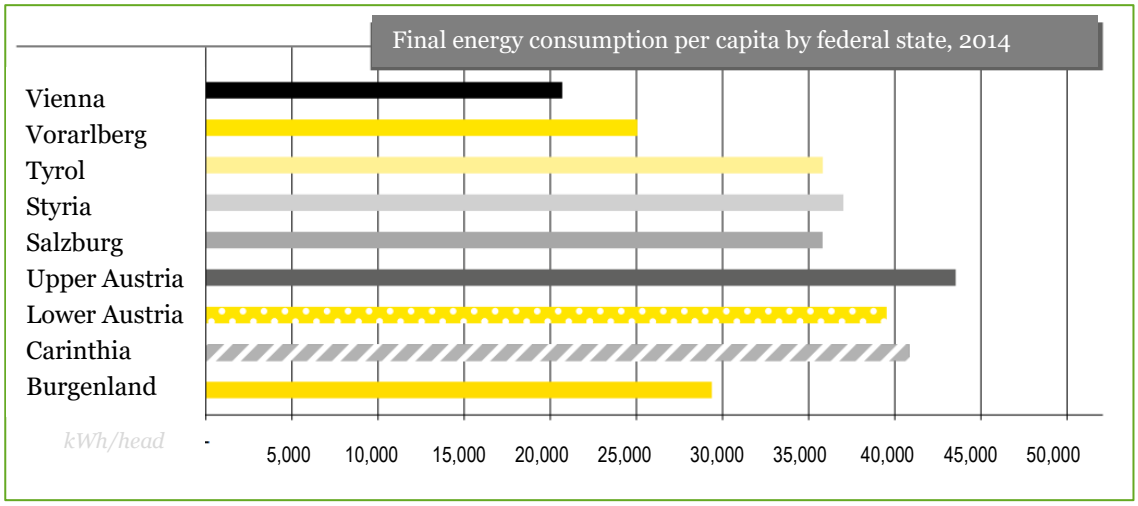
- **Reduction of per capita greenhouse gas emissions** in Vienna by 80 percent by 2050 (compared with 1990). Reduction of per capita CO_2 emissions by at least 35 percent by 2030 (compared with 1990).
- **Increased energy efficiency** and reduction of the total per capita energy consumption in Vienna by 40 percent by 2050 (compared with 2005). Primary energy usage is to be reduced from 3,000 watts to 2,000 watts per capita.
- **Renewable energy**: 50 percent of energy should come from renewable sources by 2050.
- **Mobility:** Reduction of motorised private transport from the current level of 28 percent to 15 percent by 2030. By 2050, all cars driving within city limits will be powered by alternative driving technologies.
- **Buildings:** Reduction of energy consumption for heating, cooling and hot water by one percent per capita per year.
- **Innovations:** The share of technology-intensive products exported is to increase from the current level of 60 percent to 80 percent. Vienna is one of the top five research centres in Europe.

[8] See Klimaschutzprogramm der Stadt Wien: https://www.wien.gv.at/umwelt/klimaschutz/programm/klip2/
[9] See Smart City Rahmenstrategie der Stadt Wien
https://www.wien.gv.at/stadtentwicklung/projekte/smartcity/rahmenstrategie.html

1.5 The city's energy supply

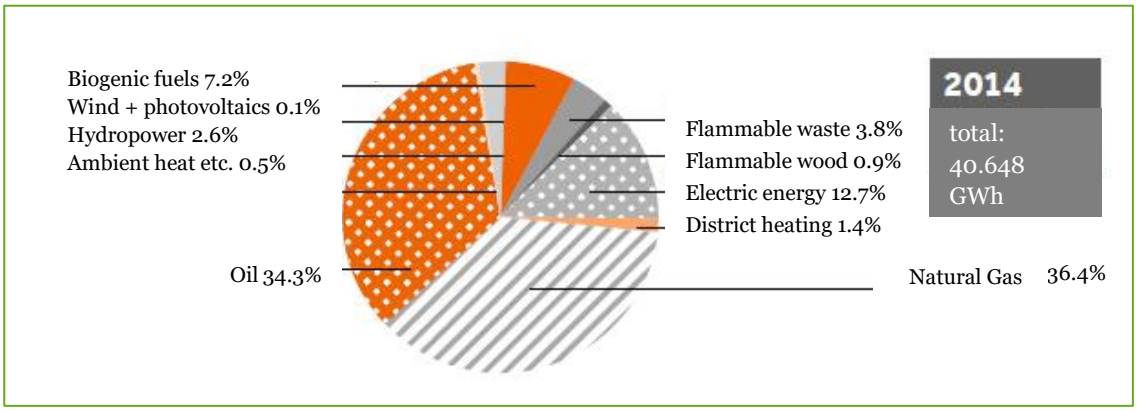
When compared with the other federal states, the city of Vienna's energy supply is characterised by spatial density and an energy-efficient supply structure. As the energy report of the City of Vienna[10] shows, Vienna has the lowest final energy consumption per capita of all the federal states.

Graph: Final energy consumption per capita per federal state (Energy Report of the City of Vienna 2016):



Gross domestic consumption has been falling steadily since 2005. The proportion of renewable energy forms in gross final energy consumption is increasing rapidly. Dependence on fossil fuels and associated energy imports is also still high. Natural gas and oil each account for one third of gross domestic energy consumption.

Graph: Gross energy consumption of the City of Vienna by energy source (Energy Report of the City of Vienna 2016):



Final energy consumption shows that transport accounts for the largest share with 38.5 percent, followed by private households (29.4 percent) and services (24 percent).

In terms of electricity production, the recent substantial increase in the proportion of renewable energy is clear to see; at the same time, however, a decline in total electricity production in Vienna is apparent. This is reflected in 2014 in the cutback of gas power plants due to the energy market situation. While electricity production from renewable energy was able to be increased by around 20 percent from 1,134 gigawatt hours (GWh) in 2005 to 1,352 GWh in 2014, total electricity production within the same time period fell from 8,323 GWh to 4,167 GWh, equivalent to around 43 percent.

[10] City of Vienna Ma 20 Energy Planning: Energiebericht der Stadt Wien 2016.

2 The energy revolution has already begun

2.1 The breakthrough of renewable energy technologies

The transformation in the energy system is no longer just a part of policy statements, but also reflected in the market developments. The shift towards decarbonisation has been underway for several years now. Energy markets have started to shift. The breakthrough of renewable energy technologies, especially in electricity production, the merging of electricity, heat, and (e-)mobility, developments in storage and intelligent grids, digitalisation and a range of policy-relevant decisions have combined to induce a transformation process that further accentuates the significance of innovation.

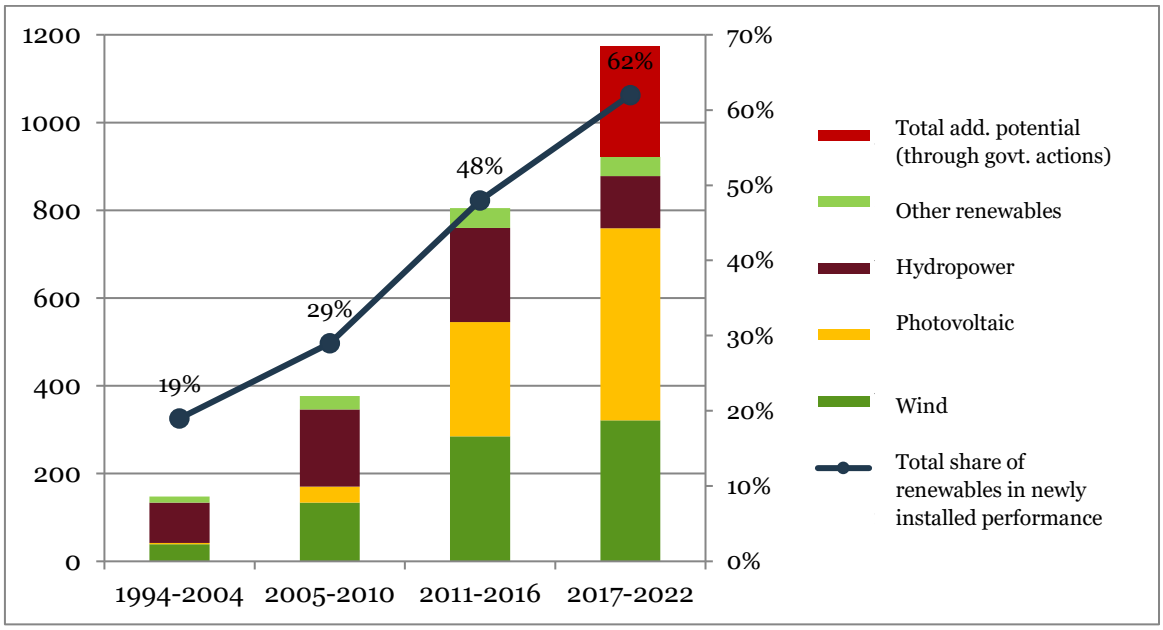
More and more countries and regions are relying on the introduction of CO_2 prices and tax incentives supporting CO_2-free technologies and imposing a heavier burden on CO_2-intensive activities. Even though this is far from covering the external costs of the environmental damage, it sends out a signal to the market. The latest market and energy reports convincingly reflect the dynamic development of renewable energy, most notably within photovoltaics.[11]

Wind and solar energy taking charge

Even the International Energy Agency (IEA), which is considered to be conservative, has revised its figures and forecasts significantly upwards.[12] In terms of energy production, renewable sources are taking charge through expansion – spearheaded by photovoltaic and wind energy. Overall, renewable energy accounted for two thirds of capacity growth within the electricity sector in 2016.

Photovoltaic facilities have shown the most recent significant growth; around 75-gigawatt (GW) was added to the grid in 2016, representing growth of 50 percent. The sum of all newly added energy capacities totalled 165 Gigawatt. In 2017, in the photovoltaic sector alone, 100 gigawatts of output is expected from new installations – and so market figures will exceed forecasts once again. High growth rates in renewable energy are expected in the future.

Graph: Development of new renewable electricity generation capacity in gigawatts (IEA 2017):



The change in the energy supply system goes hand in hand with investment figures in the billions. According to Bloomberg New Energy Finance, investment in renewable energy has amounted to an average of 300 billion US dollars worldwide every year for the past seven years. At the same time, the annual generation capacity of new

[11] See also Climate and Energy Fund/Erneuerbare Energie Österreich: Faktencheck Energiewende 2017/2018, Vienna 2017
[12] International Energy Agency (IEA): Market Report Series – Renewables 2017. Paris, 2017

installations has significantly increased thanks to substantial cost reductions: from 88 gigawatts in 2010 to more than 160 GW in 2016.[13]

Worldwide investments in energy efficiency rose by 9 percent in 2016 and currently total 231 billion USD annually. As with renewable energy sources, the major driver of growth is China. However, unlike with renewable energy, the European Union still holds the lead with a share of 30 percent of investments.[14]

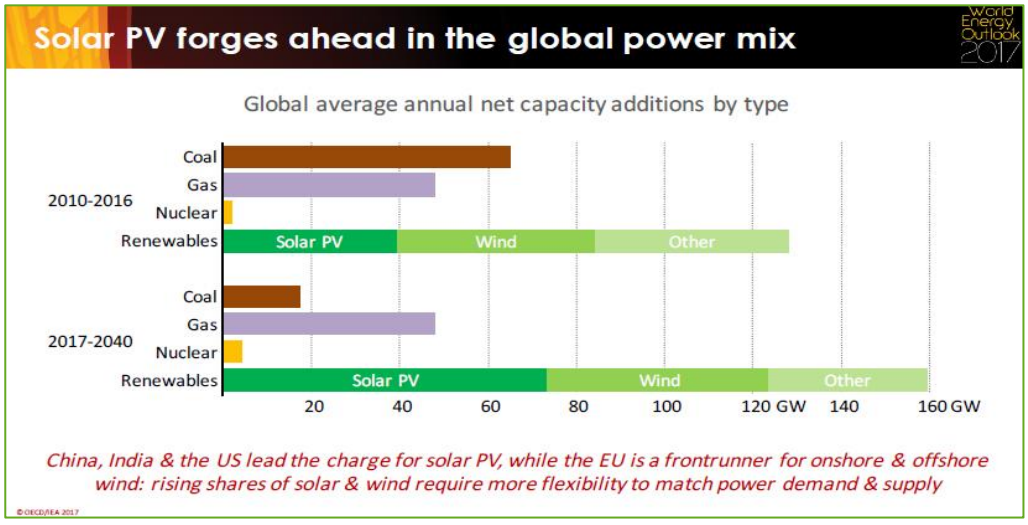
Export-oriented technology providers need a strong domestic market

Austria is in many ways characterised by very good conditions, to become a role model in terms of renewable energy. With a renewable share of around 70 percent of electricity production and approx. 33 percent of total energy production, Austria is a European leader in the field. A total of around 37,000 employees working in the renewable energy sector generate a sales volume of 6.9bn euros annually (2015).[15]

As the BMVIT report "Innovative Energy Technologies in Austria – Market Development in 2016"[16] shows, however, recent market developments have been critical. As part of this, a booming domestic market is the best basis for a prosperous export economy. In many energy technology sectors, Austrian businesses are very successful. Two out of three biomass boilers in Germany come from Austria, the export share of solar thermal collectors is at 82 percent and the export quota of wind power supply industries is at 70 percent. One in 20 employees in Austria works in the field of environmental technology, including service companies. Almost twelve percent of the gross domestic product consists of sales in environmental technology.

In a new scenario by the International Energy Agency for 2040, 80 percent of new electricity generation capacities within the European Union are based on renewable energy. In light of current strong expansion, wind energy will soon be the leading source of power. In many countries, photovoltaic is becoming the cheapest technology for new electricity-generating facilities and represents by far the largest share of new electricity generation capacities. The global use of renewable energy in heating and transport is also in the process of doubling. Good opportunities are available for Austria's technology providers in these global markets.

Graph: Worldwide annual electricity generation capacities since 2010 and the scenario up to 2040. (IEA 2017)[17]

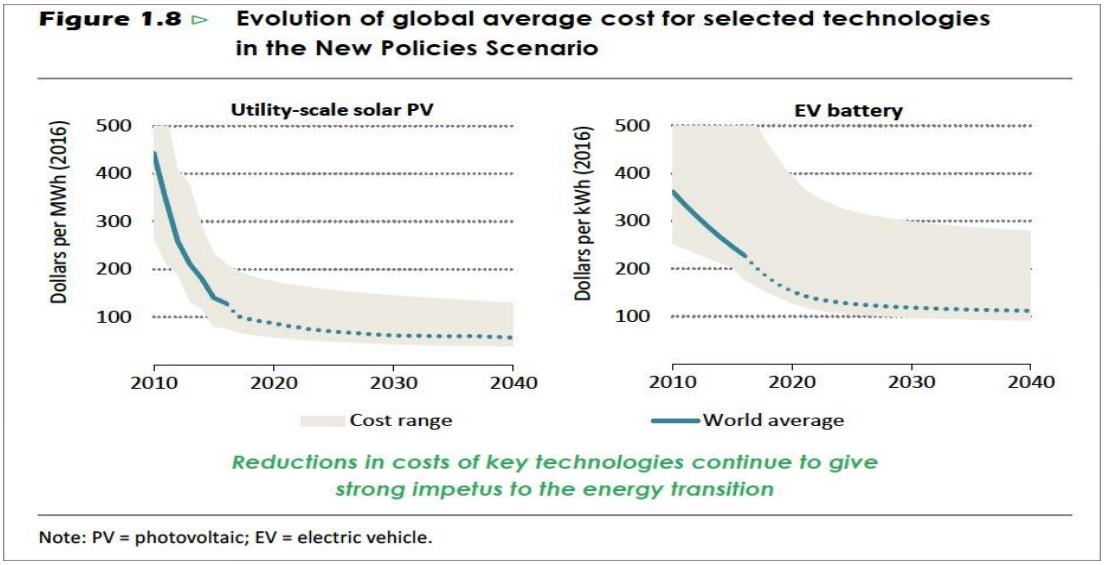


Globally, China is setting the pace, particularly in the development of photovoltaic technologies. Currently (2017), China installs around the same amount of photovoltaic systems every week as Austria has installed in the past 20

[13] Bloomberg New Energy Finance: New Energy Outlook 2017
[14] International Energy Agency: Market Report Series - Energy Efficiency 2017, Paris 2017
[15] BMLFUW: Erneuerbare Energie in Zahlen 2016. Entwicklungen in Österreich Datenbasis 2015, Vienna 2017
[16] BMVIT: Innovative Energietechnologien in Österreich - Marktentwicklung 2016. Biomasse, Photovoltaik, Solarthermie, Wärmepumpen und Windkraft. Markterhebung 13/2017
[17] IEA World Energy Outlook 2017

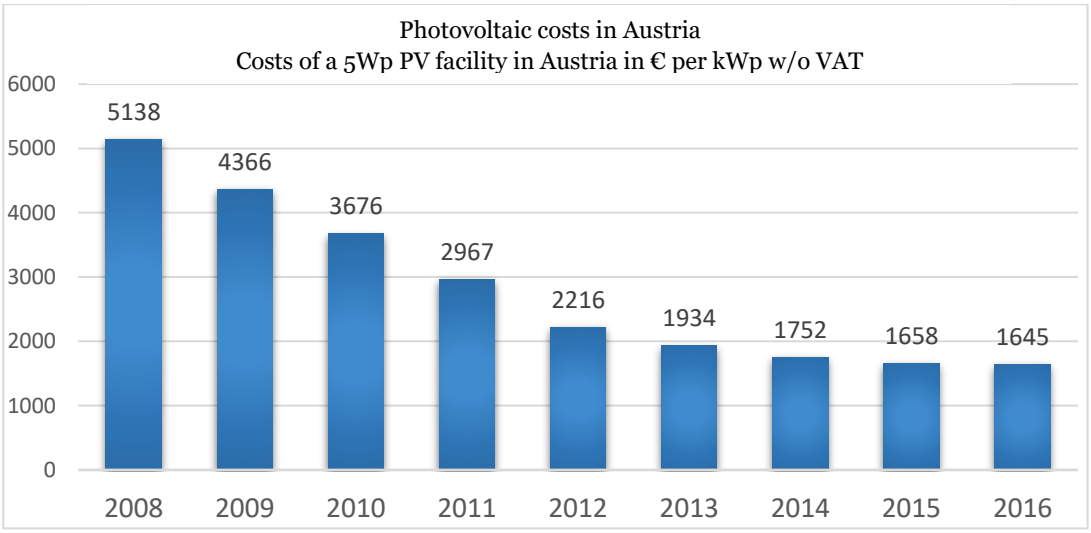
years put together.[18] The vast expansion has also contributed to reductions in the cost of photovoltaic units – and simultaneously for batteries used in electric vehicles. Around the world, co-called levelized costs of electricity - the costs involved in transforming a form of energy into electric power - have halved for wind power since 2009; with photovoltaic systems, these have fallen by 80 percent since 2008:[19]

Graph: Development of costs for photovoltaic and battery technologies (Li-Ion battery) (IEA 2017)[20]



Cost reductions and technological developments are also apparent in Austria. Over the past 8 years, the cost of photovoltaic systems has fallen by 68 percent.

Graph: Cost development for a 5 kWp photovoltaic system in Austria[21]



[18] Statements from lecture by Hubert Fechner "Neue Produkte und Dienstleistungen der erneuerbaren Energiezukunft" as part of the 3rd business meeting "Urbane Energieinnovationen" 9.11.2017
[19] BNEF: Bloomberg New Energy Outlook 2016. London, 2016
[20] IEA World Energy Outlook 2017
[21] Biermayer, Leonhartsberger, Fechner et al., Innovative Energietechnologien in Österreich - Marktentwicklung 2016. BMVIT Schriftenreihe 06/2017, May 2017

2.2 Decarbonisation, decentralisation, digitalisation and services

This rapid technological development may be a starting point for enabling a decentralised energy system that integrates local energy production, based on renewable energy as well as the mobility and heat sectors. Developments in the field of storage are particularly relevant here, as evidenced by declining prices for batteries over recent years with concurrently rising energy density.

Greater flexibility will be required in the future, as not only is consumption fluctuating, but so too is energy production. The energy system of the future therefore requires more than just switching energy sources; it requires chances in the whole system.

The great transformation in the renewable energy sector coincides with the parallel major trend of digitalisation. The drivers of change also include social trends such as urbanisation, the sharing economy and behavioural changes. More flexibility, the involvement of consumers, new business models for utilities and service providers and new demands on energy infrastructure are changing the characteristics of energy supply. The systemic change in the energy system is strongly influenced by an integrated approach with intelligent technologies and control systems.

Digitalisation provides the radical change

The energy sector is anticipating huge effects from digitalisation.[22] According to a study by the Austrian Energy Agency, it is not the sector itself that will benefit in first place, but rather energy-related start-ups and established ICT businesses will reap the rewards. New forms of cooperation should therefore ensure greater innovation. Energy companies are transforming from pure suppliers to service providers. The most important services for final customers include energy efficiency and management, analysis and mobility services. Low profitability and legal frameworks are currently considered to be the main obstacles.

Systems integration will assume a major role in the development of business models.[23] Relevant issues include: *How can we create attractive offers for renters? How can we connect consumers and producers (of renewable energy) with each other to achieve an optimal result at both local and regional levels? How can new financing models and alternative currencies spur the use of renewable energy/intelligent energy systems?*[24] Innovative business models are needed, including in the fields of "Digital products/Product as a Service", "Digital Utility/the digital energy company" and "new financing models". The (industrial) Internet of Things, data analytics, artificial intelligence and the Blockchain represent some of the opportunities for new business models.

The International Energy Agency also identifies dramatic changes in a recently published report on digitalisation and the energy economy. Precise process control is possible with recent developments in digitalisation, and this allows for gains of around 185 gigawatts in flexibility in buildings (Smart Home), industry (Industrie 4.0) and mobility (electric vehicles). In addition, costs of up to 270 billion dollars (232.4 billion euros) can be avoided, which would otherwise have to be invested into new infrastructure. According to the IEA's estimate for the year 2040, more than one billion households and eleven billion intelligent devices worldwide will be connected to each other and able to communicate. The report also warns of the risk of cyber-attacks.[25]

Concepts for the urban area

A major energy consumer such as the City of Vienna will not be able to satisfy its energy demand solely through domestic production, which is why the exchange with the surrounding area is so important. The goal must be to achieve a 40-50 percent reduction in energy demand through both switching to e-mobility and increasing efficiency in the building sector. The urban area offers waste heat and optimum conditions for a combined heating and power system from biogenic fuels, waste, gas and hydrogen from renewable sources.

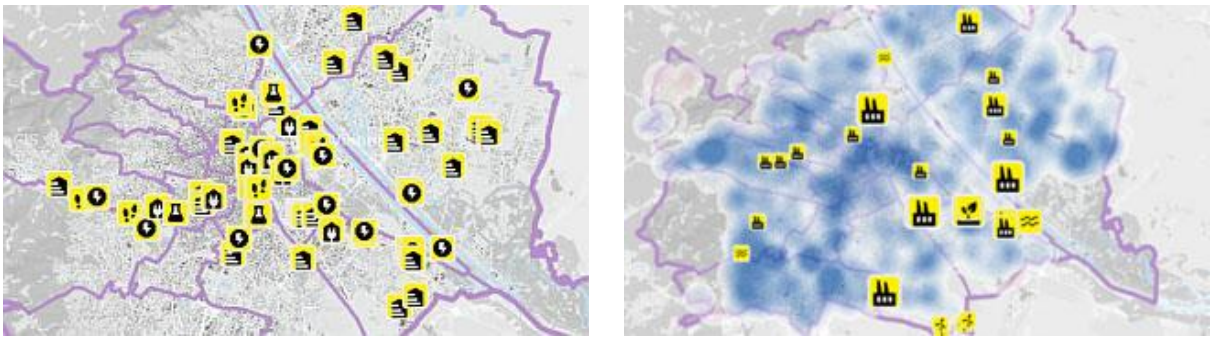
[22] Austrian Energy Agency: "Digitale Transformation der Energiewelt", Vienna 2017
[23] See Roger Hackstock: Flexibel und frei. Wie eine umfassende Energiewende unser Leben verändert. Oekom 2017.
[24] From lecture by Hemma Bieser, Pioniere der Energiewende – Chancen der Digitalisierung, 1st business meeting 11.9. 2017
[25] International Energy Agency (IEA): Digitalization and Energy, 2017.

3 Innovation on Urban Energy

While the challenges, questions and current trends in designing energy systems can be clearly defined, the image of our energy future still features numerous variables. In this chapter, some of the topics that play a role in the development of innovations, products and services in the urban energy supply will be described. This brief overview does not claim to be complete; instead it may be assumed with certainty that new innovations will have been developed in a few years that are not yet well-known and some of them could be of a disruptive nature. There are many indications that some energy innovation will not originate from the energy sector itself, but rather from other areas such as information technology. Innovation on urban energy not only a question of technological solutions, but also of social innovation. They involve implementing new technologies through socially accepted applications, but at the same time social approaches independent of technological innovations are required to transform the energy system. Avoiding the so-called rebound effect is one example of this.

In addition to specific projects in Vienna, one indicator for the following topics is the Austrian Energy Research and Innovation Strategy published by the bmvit and the Austrian Climate and Energy Fund in 2017[26], which was developed and discussed by numerous experts in a strategy process.

Best-practice energy projects
In terms of the implementation of new energy technologies, Vienna is an innovative city on an international level. This is proven by a number of projects which provide convincing examples of future-oriented design of sustainable energy supplies implemented in practice. The city of the future is based on the knowledge and ideas of people living in Vienna who initiate new projects, suggestions and visions in research institutions, companies or as individuals. Vienna is the site of many innovative ideas and energy projects in various sectors: whether in energy supply, architecture, knowledge and skills transfer, technological development or in the development of new urban quarters. Several specific projects from Vienna are detailed in the City of Vienna's knowledge database "Innovative Energy Projects". The database is continually expanded and added to and is aimed at motivating other players to develop and implement sustainable projects, as well as making successful innovations the new standard. These best-practice energy projects can be found on the wien.at city map as well as in the Energy!ahead Vienna app. A comprehensive update will be carried out in 2018, which will also take into account new innovative projects.[27]



Images from the themed map "City of Vienna Energy" (Photo: ViennaGIS)

3.1 Energy efficiency

Energy efficiency is an indispensable key for the success of the energy transformation.

Lowering energy consumption in existing buildings
The construction sector is and remains a key factor not only in new areas of urban development, but also in existing buildings. Innovative reconstruction concepts and strategies as well as processes and technologies for sustainable refurbishment remain significant in both housing and service buildings. In addition to heating demand (room heating and hot water), the increasing need for cooling in many buildings, in itself a consequence of climate change, must be addressed. Objectives include the use of highly efficient and ecological insulation components and building materials, the reduction of harmful substances/allergens and the development of materials with

[26] bmvit/Klima und Energiefonds: Energieforschungs- und innovationsstrategie, Vienna 2017
[27] See https://www.wien.gv.at/stadtentwicklung/energie/beispiele/vorzeigeprojekte-app.html

minimal grey energy consumption and greenhouse gas emissions. Highly efficient and cost-effective building service systems (heating, cooling, ventilation, water heating) are important elements of a low energy demand.

Example: Technische Universität (TU) Wien - Getreidemarkt
Various model examples in Vienna show that refurbishments have an enormous potential for savings. For example, the former chemistry tower of the TU Wien underwent general refurbishment to become Austria's largest plus-energy office building and, in the process, became an international model. The project is unique worldwide due to the implementation of this standard in an existing tower block from the 1970s as well as the requirement to provide energy not only for the building's operation directly on location but also for the entire demand of around 800 employees and students.

The building envelope has integrated sun protection; the rooms are temperature-controlled by means of efficient cooling and heating of the floor (component activation), the recycling of server waste heat and a highly efficient cooling system. Intelligent building management and control as well as green IT reduce energy demand, as do optimised lighting systems and an intelligent electricity grid which disconnects devices from electricity consumption when they are not in use. Thanks to the optimisation of over 9,300 individual components, the energy demand - reduced by up to 93 percent - can be satisfied without loss of comfort by the PV system built into the roof and facades as well as energy recovery from the lift system.

New construction
In the new construction sector, Vienna also has a very good tradition of achieving a low energy consumption through innovation and good planning. Adressing the goal of greenhouse gas neutrality, the decades-long emissions effect of newly constructed buildings - both in housing as well as the service sector - must be taken into account. Here, a relatively new keyword, "digital construction", enters the discussion. This ensures the development of solutions for the optimum use of modern IT systems with regard to energy and resource optimisation (e.g. forecasts for electricity, heating and cooling requirements) as well as improved quality and cost optimisation in the construction process and during use. As a long-time world capital for passive building, Vienna has gone the extra mile in terms of awareness.

Example: Technologiezentrum Seestadt

The Technologiezentrum Seestadt is a centre for research-oriented companies and research and development institutions in Aspern Seestadt in Vienna. The planning process including the incorporation of construction physics, thermal building simulation, daylight simulation and construction ecology enabled the primary energy requirements of the Plus-Energy building to be optimised accordingly.

At Technologiezentrum Seestadt, the office rooms are heated and cooled by means of concrete core activation. First of all, the exhaust heat is recovered from the server rooms using small heat pumps, collected in buffer tanks, removed if necessary and distributed through concrete core activation. District heating is also available to cover peak loads. For cooling, ground water is used or in the transitional period, due to higher efficiency, a heat exchanger on the building's roof is automatically switched on (so-called "free cooling"). The Plus-Energy standard is satisfied by means of electricity generation from the photovoltaic system on the building, which provides a top performance of 140-Kilowatt Peak on a total surface area of 1,300m². The passive building standard guarantees a high insulation standard, low thermal bridge designs and energy-efficient and low-emission operation of the building operation by way of an airtight, compact building envelope.

Example: Student guesthouses as passive buildings

Vienna hosts multiple student guesthouses in passive house standards. The Guesthouse on Molkereistraße was the world's first passive student guesthouse, built in 2005. At Sonnenallee 41 in the new quarter of Seestadt Aspern, three housing organisations operate one of the most modern student dormitories in the world. GreenHouse, which was opened in 2015, comprises three building sections with a total of 313 living spaces, characterised by an ideal combination of high energy efficiency and the use of renewable energy. It is therefore the first student guesthouse in the world to reach the passive building "Plus" standard. The roof surface is used to obtain solar energy via a photovoltaic installation: the system with 244-Kilowatt Peak (kWp) of installed capacity produces more electricity than required; internal battery storage is charged with the excess electricity, guaranteeing a constant power supply.

Future topic: Energy-flexible buildings

Buildings are gaining a new function in the energy system. They are no longer only consuming, but are increasingly serving as energy producers and energy stores. The adaptation of building energy consumption and building associations to future energy production from renewable energy sources is becoming a more central focus. It will be necessary to be able to use short-term predictable yet variably generated amounts of energy - for example, from wind or solar power but also from solar thermal systems - in a more targeted way.

The heat storage capacity of building components, the number and size of hot water boilers and batteries, the outfitting with electrical devices and users (e.g. heat pumps), the regulation systems in use and many more factors determine the potential for "energy flexibility" in buildings. Their intelligent use should displace peak loads and use electricity and heating grids at the right time.

Energy planning for city districts and quarters

Smart, proactive planning of new city districts and quarters provides the basis for keeping energy consumption in the city at a low level. The challenge is aligning the energy production and distribution to the location and demands of the energy consumer, both spatially and structurally. Aspects of urban planning flow into the project development and planning processes for energy supply to guarantee the optimum use of potential and innovations. Energy-oriented planning tools for the integrated planning and design of city districts will be important in this, as will be the development of new, transparent daylight building structures for concentrated building methods and energy-efficient lighting concepts. A further central issue is the use of regional exhaust heat for existing buildings (technologies, systems, concepts) and the development of concepts and strategies for the orderly dismantling of buildings with regard to the re-use and recycling of building materials (urban mining).

Example: Manner - Exhaust heat use from the production process

The long-established Manner company modernised their main factory in Vienna's Hernals district in 2016. Since then, one million hazelnut waffles have been produced every day in an innovative "vertical" production chain covering several storeys – and the excess heat from the baking process is used to supply the vicinity with district heating. The project, which was supported by the City of Vienna and the TU Wien, combines the production process with the heat supply in an energy-efficient way. Here, excess heat from the baking process is fed into the local district heating grid for a distance of 3.5 kilometres. With a performance of one megawatt, 600 households and operations in Ottakring and Hernals are supplied with heating and hot water. In summer, the exhaust heat can be transformed into cold air and used in the implementation of cooling processes. Since energy generation and energy consumption are intrinsically connected, this innovative system is especially efficient. This system results in a saving of 1,000 tonnes of carbon dioxide each year – this is equivalent to the CO_2 emissions of 240 single-family homes.

Energy efficiency in processes

A distinction can be made between low temperature and high temperature applications (industry) in individual applications. The use of new technologies and new procedural techniques can contribute significantly to savings. In business, energy consumption can be reduced by means of technological as well as logistical measures.

3.2 Sustainable energy production

The growth of renewable energy provides a stable foundation for the establishment of a sustainable energy system. For the greater city, the exchange relationship with the surrounding area in particular must be taken into account. Photovoltaics and wind power will also play a key role in the proposed decarbonisation of the electricity sector, as will the well-developed hydropower in Austria. It is generally expected that the proportion of electricity in the energy mix – given the costs of fossil fuels in the heating and mobility sector – will rise further. The following offers a brief overview of renewable energy technologies.

Photovoltaic power: Photovoltaic denotes the direct conversion of solar energy into electrical energy using solar cells. Photovoltaics should not be confused with solar heat (solar thermal energy), in which the heat of the sun is used for heating purposes (hot water or heating support). In Vienna, annual solar radiation amounts to around 1,100 watts per m². Out of Vienna's 52km² of roof area, more than 29km² (55 percent) are technically suitable for the use of solar energy. A Solar Potential Map, available online, illustrates the technical opportunities for solar energy use in the city. In future, the opportunity to use photovoltaic systems in apartment buildings as well will allow for new models. In such cases the output of the photovoltaic system will be divided financially among the different apartments.

Example: Citizens' solar power plant:
In May 2012, the first Viennese citizens' solar power plant went into operation on the grounds of the Donaustadt Power Plant. The success of this project gave the green light to the successful model, and subsequently a number of other cooperative power plants have been constructed, all planned and implemented by operator Wien Energie. This provides an easy way for Viennese citizens to participate in the expansion of renewable energy.

Wind power: Although the potential for wind power in urban areas is limited, it is still relevant for Vienna's energy supply due to the exchange relationship with the surrounding area. Certain locations within Vienna are also used. Especially in metropolitan areas, small wind turbines could supplement the energy supply.

Hydropower is the most important source of energy production in Austria. The operation and use of hydropower produces no emissions at all. Fully half of Austria's energy needs can be met by hydropower. Even in Vienna, hydropower contributes significantly to renewable gross final energy in electricity. Several power plants are located outside of Vienna.

Example: Small hydropower plant in Nussdorf:
In addition to large river power stations, hydropower can also be used efficiently in small systems. For example, a modern small hydropower plant was integrated near the beginning of the Donaukanal in Vienna's Nussdorf district in the historical Nussdorf weir. This has generated the necessary electricity for around 8,000 households since the beginning of operations.

Biogas and biomass: Biomass is one of the most prominent and most frequently used energy sources in Austria. The use of biomass is an important component of all climate- and energy policy-related objectives, as biogenic fuels are CO_2-neutral and renewable. No more CO_2 is emitted during the burning process than is absorbed in growth via plant photosynthesis. The focus of the energetic use of biomass is traditionally in heat provision. With regard to electricity production, the largest biomass power plant in Austria is in Vienna's Simmering district.

Example: Biogas Wien
In 2007, the first biogas facility in Vienna began operations; since 2015, the biogas produced has been converted into biomethane in a processing plant and directly fed into the natural gas grid. 22,000 tonnes of organic waste from organic waste bins as well as food waste from Vienna's commercial kitchens and other sources are processed in this facility and biochemically converted in the fermenter every year.

Example: ebswien wastewater treatment plant
The Viennese wastewater treatment plant is becoming an ecological power plant. From the year 2020, ebswien will be able to produce all the energy required for wastewater treatment from sewer gas. This will reduce CO2 emissions by around 40,000 tonnes per year. The core of the project is the decomposition of the sewage sludge to obtain heat and electricity. To do so, the sludge being treated is anaerobically stabilised in six 35m-high septic tanks. The sewer gas produced will be converted into electricity via a cogeneration unit.

Geothermal energy: Geothermal energy refers to the heat store in the ground. In Vienna, geothermal energy is normally used with the aid of geothermal heat probes or groundwater heat pumps. It is perfectly suited to providing buildings with air-conditioning. The subsoil can also be used as a seasonal underground storage tank, for example, to use the excess summer heat during the coming winter. In the Vienna area, favourable conditions for the energetic use of groundwater and near-surface geothermal energy prevail – the Viennese Map of Areas with Geothermal Potential offers an overview of sites.

Example: Vienna University of Economics and Business – heating and cooling with geothermal energy:
The Vienna University of Economics and Business (WU Wien) campus, which was completed in 2013, comprises six large building complexes on a site of around 90,000m² and provides space for 25,000 students and 1,500 employees. The centrepiece of the WU Wien's energy supply is one of the largest facilities for thermal groundwater use in Austria. 70 percent of the required heating and cooling energy for the campus is generated by geothermal energy. For this process, up to 150 litres of groundwater are extracted every second and the building components are "activated", that is, the ceilings and walls are heated or cooled via a pipe system. In summer the water cools directly, while it is preheated using waste heat from the computer centres in the winter.

3.3 Energy storage

In view of the volatility of solar and wind power, efficient energy storage (electrical, thermal, mechanical and chemical) plays a key role. This primarily involves decentralised energy storage with a simultaneous local gain of renewable energy in buildings, areas and estates. If the electricity is converted before being stored, for example into hydrogen or other chemical energy sources, there is an opportunity to use the energy in other energy-efficient sectors in addition to new power generation, and in this way to connect different sectors.[28]

Buildings as stores: As shown in several of the previous examples, the activation of building components is used for local thermal and energy storage. Through the integration of electricity, heat and mobility, new opportunities are presented for the flexible handling of energy. Intelligent interfaces for energy generation and use in various forms are required (e.g. storage of excess solar and wind energy within the building during the day, energy transfer into an electric vehicle overnight).

Heating/cooling store: Heating/cooling stores already have a variety of functions in current energy systems. Areas of application range from the construction sector and grid-connected heating supply facilities to industrial applications. Improvements in energy efficiency, increased proportions of renewable heat and the improvement of the economic efficiency of energy systems are key factors here. In terms of thermal stores, Austria plays a leading role within Europe.

[28] See also: bmvit/Klima- und Energiefonds: Energieforschungs- und innovationsstrategie, Vienna 2017

Comet (Competence Centres for Excellent Technologies) K-Project Green Storage Grid
Within the Comet-K Project GSG-GreenStorageGrid, relevant technologies such as thermal, chemical and hydraulic stores are seen as directly connected to the grid and are optimised using simulation methods. Measurements are taken at real facilities and used to validate models. The project is funded within the COMET framework by the BMVIT, the BMWFW, the Vienna Business Agency and the Regional Governments of Lower and Upper Austria.

E-mobility: Electric vehicles are able to play an important role in an intelligent electricity grid or as storage thanks to their storage function. Bidirectional charging and corresponding load management will in future facilitate the use of e-car batteries intelligently and efficiently as storage devices. In this way, energy stored can be returned to the electrical grid and cost-effectively drawn from the grid again. By the end of 2020, 1,000 new e-charging stations will have been established in Vienna.

3.4 Intelligent urban energy systems

In the IEA technology report "Energy Technology Perspectives 2016 – Towards Sustainable Urban Energy Systems"[29], cities and urban areas play a key role in the implementation of sustainable energy systems and the achievement of climate objectives. The amalgamation of the various components is essential to further development of the energy system, due to intelligent management.

Urban districts and quarters: The multifunctional nature of buildings in the future energy system - in interplay and interaction with other urban infrastructures - is essential. Buildings and estates should therefore be examined throughout their entire life cycle. Mobility plays a central role. In addition to propulsion technologies, innovations in the transport system are also of great value. Utilisation and systems innovations in the context of intermodal transport mobility concepts and general area field approaches (e.g. mobility and regional development, mobility and health) are necessary.

Smart Grids: The term "Smart Grids" refers to the communicative networking and management of electricity production, storage, electrical consumers and grid operations in the transmission, distribution and supply of electricity. The advantages of Smart Grids are increased reliability, a greater degree of facility use, better integration of plug-in electric vehicles and energy from renewable sources, reduced operation costs for energy producers, lower energy expenses for households and businesses, increased efficiency, fewer greenhouse gas emissions and other pollutants. Bidirectional intelligent electricity meters support demand management and create incentives for consumers to play an active role in energy systems.

Example: Aspern Smart City Research (ASCR)
Seestadt is home to an ideal-typical model of research and application: the ASCR. "Smart users" are involved in predictive building automations and the use of building energy flexibilities. Furthermore, methods for recording grid status and grid planning are being developed. All solutions are based on a cross-discipline ICT sector, for which suitable big data models are being developed and tested.

Summary and outlook
It can be concluded that innovation on urban energy in a wide variety of areas offers a number of positive perspectives, which also represent an opportunity for the development of Vienna as a business location. New ideas, projects, collaborations and players will transform the energy landscape beyond our borders and make innovation a decisive factor in the future of energy.

This technology report concludes with a list of relevant institutions in this sector in Vienna. All relevant organisations and research institutions listed on the Technology Platform at the time of the creation of this technology report are listed in point "5. Businesses on the Technology Platform", and give a good overview of activities in Vienna in the field of "innovation on urban energy".

[29] International Energy Agency: Energy Technology Perspectives 2016 - Towards Sustainable Urban Energy Systems, 2016

4 Institutions in Vienna

Institutions in Vienna			
Institution	**Description**	**Contact**	**Website**
AIT – Austrian Institute of Technology	The AIT Austrian Institute of Technology is Austria's largest extramural research institute and is regarded as a specialist in central infrastructure issues of the future. Around 1,300 employees carry out research throughout Austria - particularly at the main locations of Wien Tech Gate, Wien TECHbase, Seibersdorf, Wr. Neustadt, Tulln, Ranshofen and Graz. The focus areas relevant to energy include Complex Energy Systems, Battery Technologies, Photovoltaics, Smart and Resilient Cities, Smart Grids.	Donau-City-Straße 1 1220 Vienna Tel: +43 50550-0 office@ait.ac.at	www.ait.ac.at
Aspern Smart City Research Gmbh & Co KG (ASCR)	The Research Society was founded by Siemens, Wien Energie, Wiener Netze and the City of Vienna (Vienna Business Agency and Wien 3420) in 2013. Here, technical solutions for the future of energy are developed and used in real life in the newly constructed urban quarter of Seestadt Aspern. The Society works on, among other things, predictive building automations and the use of building energy flexibilities, also in the energy market – and all this takes place with the involvement of "smart users".	Seestadtstraße 27 1220 Wien Tel.: +43 (0)1 908 93 69 office@ascr.at	www.ascr.at
Austria Solar	All reputable thermal solar facility providers are assembled within the Austria Solar Association. Overall, the association represents the interests of over 220 companies in the solar sector, an industry with almost 3,500 employees.	Mariahilferstraße 89/22 1060 Wien Tel. +43 1 5811327 11, office(at)austriasolar.at	www.solarwaerme.at
Climate KiC Accelerator	European research, development and/or innovation projects are funded within the Climate KIC. Austrian players have the chance to take part.	Limmatstrasse 264 8005 Zurich Schweiz Tel: +43 (0) 67 650 522 84 Johannes.Naimer-Stach@climate-kic.org	www.climate-kic-dach.org
Energy Center Urban Innovation Vienna	Urban Innovation Vienna (UIV) is a company of the Wien Holding group and supports the City of Vienna in the field of Smart City Wien as well as the thematic areas of energy, ICT and urban future. UIV was formed from TINA Vienna and the Europaforum in 2017. The Energy Centre fulfils its role as an independent competence centre for energy, and supports the City of Vienna in achieving its ambitious energy and climate protection goals. Priority activities include supplying consultancy services to the city, its departments and businesses.	Operngasse 17-21 1040 Wien Tel: +43 1 4000 842 60 office@urbaninnovation.at	www.urbaninnovation.at
Erneuerbare Energie Österreich	The Erneuerbare Energie Österreich (Renewable Energy Austria - EEÖ) umbrella association is the union of the most important interest associations in the renewable energy sector. The central objective of EEÖ is to convert Austria's energy supply to renewable energy sources in the medium term and to create long-term framework conditions for expanding renewable energy sources.	Neubaugasse 4/7-9 1070 Wien Tel: +43/01 522 0766- 60 office@erneuerbare-energie.at	www.erneuerbare-energie.at

Institution	Description	Contact	Website
FH Technikum Wien **Institut für erneuerbare Energie**	The Department of Renewable Energy at the University of Applied Sciences performs research and consultancy projects in the future-oriented field of renewable energies. These projects ensure that instruction is offered in an international context and is based on current research results. These projects guarantee teaching in an international context on the basis of current research results. The international positioning and connection to global research and development trends is secured via active work in diverse research groups of the International Energy Agency and EU technology platforms.	ENERGYbase, Giefinggasse 6 1210 Wien +43 1 333 40 77-0 info@technikum-wien.at	https://www.technikum-wien.at/en/about-us/departments/department-renewable-energy/
klimaaktiv	klimaaktiv is the Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW)'s climate protection initiative. With the development and provision of quality standards, training and further specialist training, consulting, information and a large partner network, klimaaktiv complements existing climate protection sponsorships and regulations. Its areas of focus are within the areas of construction and renovation, saving energy, renewable energy and mobility.	Österreichische Energieagentur klimaaktiv Management Tel. +43(0)1 586 15 24 - 0 klimaaktiv@energyagency.at	www.klimaaktiv.at
Klima- und Energiefonds	The Climate and Energy Fund of the Republic of Austria views itself as an impulse generator and innovative power for climate-related and sustainable energy and mobility technologies. The fund promotes ideas, concepts and projects in research and development, market penetration and building awareness.	Gumpendorfer Straße 5/22 1060 Wien, Österreich Tel. +43 (0)1 585 03 90 office@klimafonds.gv.at	www.klimafonds.gv.at
ÖGUT	The Austrian Society for Development and Technology (ÖGUT) is a decision maker and platform for sustainable development. With a professional range of services, the ÖGUT connects around 110 organisations and institutions from economics, administration, science and environment.	Hollandstraße 10/46 1020 Wien. Tel.: +43 1 315 63 93 office@oegut.at	www.oegut.at
Österreichs Energie	Österreichs Energie (Austria's Energy) is the interest group of the Austrian E-Wirtschaft (E-Business) company. It represents jointly developed industry interests in regard to policy, administration and public relations.	Brahmsplatz 3 A-1040 Wien Tel +43 1 501 98-0 info@oesterreichsenergie.at	innovation.oesterreichsenergie.at www.oesterreichsenergie.at
Österreichische Energieagentur	The Austrian Energy Agency is the competence centre for energy and advises decision makers from politics, business and administration on a scientific basis.	Mariahilfer Straße 136 1150 Wien Tel: +43 (0)1-586 15 24 office@energyagency.at	www.energyagency.at
Österreichische Forschungsförderungsgesellschaft (FFG)	The Österreichische Forschungsförderungsgesellschaft (Austrian Research Promotion Agency) is the national funding institution for business-related research and development in Austria.	Sensengasse 1, 1090 Wien Tel: +43 (0)5 7755 – 0 office@ffg.at	https://www.ffg.at/content/das-nationale-angebot-f-r-die-energie-und-umweltforschung
Photovoltaik Austria	The Bundesverband Photovoltaik Austria (Austrian Federal Photovoltaic Association) is an inter-company and inter-party interest group that prioritises the improvement of framework conditions for photovoltaics in Austria.	Neustiftgasse 115A/19 1070 Wien Tel: +43 (0)1 / 522 35 81 office@pvaustria.at	www.pvaustria.at

Institution	Description	Contact	Website
Stadt Wien MA 20 Energieplanung	The activities of the MA 20 on Energy Planning include the coordination and further development of energy-related concepts and energy strategies as part of comprehensive urban strategies such as the Smart City framework strategy and the climate protection programme. In addition, their areas of responsibility include the coordination and further development of energy spatial planning as per the Urban Development Plan for 2025, control with regard to achieving the goals of existing energy-efficient concepts as well as recommending measures for these. Further areas are the organisation and provision of funding for renewable heating as well as involvement in the organisation and provision of other energy-related funding, the energy-efficient evaluation of projects in official procedures and the development of pilot projects for driving forward new energy technologies, especially in conjunction with municipal businesses.	Rathausstraße 14-16, 3. Stock 1010 Wien Tel: +43 1 4000 88305 Kontaktformular: wien.gv.at/kontakte/ma20/ post@ma20.wien.gv.at	www.wien.gv.at/stadtentwicklung/energie
Stadt Wien Förderstellen **MA 25 und MA 50**	The municipal departments of Urban Renewal and Inspecting Authority for Residential Buildings (MA 25) and Housing Promotion and Arbitration Board for Legal Housing Matters (MA 50) arrange numerous energy-related grants in housing.	Tel MA 30: +43 1 4000 8025 Tel MA 50: +43 1 4000 74860 post@ma25.wien.gv.at post@ma50.wien.gv.at	www.wien.gv.at/wohnen/wohnbautechnik/foerdern/index.html http://www.um-haeuser-besser.at
Stadt Wien Klimaschutz-koordination	The Executive Office (MD) for the Coordination of Climate Protection Measures negotiates activities in the fields of climate protection planning, raising awareness, climate change adaptation and climate research.	Rathaus 1, Stiege 5, 2. Stock, Zi. 504/505. 1010 Wien post@md-kli.wien.gv.at	www.wien.gv.at/umwelt/klimaschutz
Technologie-plattform **Photovoltaik Austria**	The "Technologieplattform Photovoltaik Austria" association (Technology Platform for Photovoltaics Austria - TPPV) was founded as a joint initiative of photovoltaic production operations in Austria and related Austrian research institutions in May 2012. Innovation research for the domestic photovoltaic economy should be optimised to achieve more Austrian value-added shares in the global photovoltaic industry.	Mariahilferstraße 37-39 1060 Wien info@tppv.at	www.tppv.at
TU Wien **Energy Economics Group (EEG)**	The Energy Economics Group (EEG) at the Technical University of Vienna (TU) conducts research and education in the fields of Energy Markets, Climate Change, Renewable Energy, Energy Modelling and Sustainable Systems.	Gusshausstrasse 25-29 1040 Wien Tel: +43(0)1-58801-370303 frey@eeg.tuwien.ac.at	eeg.tuwien.ac.at
Wien Energie GmbH	Wien Energie GmbH (Vienna Energy) is an energy company under the umbrella of Wiener Stadtwerke. Wien Energie is the largest energy supplier in Austria. Wien Energie is involved in supplying around 2 million customers, 230,000 commercial and industrial facilities and 4,500 agricultural operations in Greater Vienna with electricity, natural gas and heat.	Thomas-Klestil-Platz 14, 1030 Wien Tel.: +43 1 4004-0 Kontaktformular	www.wienenergie.at
Zentrum für Globalen Wandel & Nachhaltigkeit	The Centre for Global Change and Sustainability was founded in 2010 and promotes networking, the exchange of ideas and cooperation in climate, global change and sustainability - both internally (between University of Natural Resources and Life Sciences, Vienna - BOKU institutes and departments) and externally (on a local, national and international level). Its objective is to promote sustainability institutionally at BOKU and to promote and support sustainable projects, initiatives and people as a contact point - with know-how, technical competence, contacts, visibility and foresight.	Universität für Bodenkultur Wien Borkowskigasse 4 1190 Wien Tel.: +43 1 47654-99100 globalchange@boku.ac.at	http://www.boku.ac.at/wissenschaftliche-initiativen/zentrum-fuer-globalen-wandel-nachhaltigkeit/

5 Organisations on the Technology Platform

Organisations (Technology Platform)			
Organisation	**Description**	**Contact**	**Website**
1stLevelSolar GmbH	1stLevelSolar provides fully developed photovoltaic solutions to private households and companies of any size and bases its services on competent support, state-of-the-art goods and reasonable prices. Together with SunDrops, 1stLevelSolar GmbH developed a mobile solar power plant with a variety of functions: these include an electricity generator with battery storage, pump system for agriculture and drinking water treatment with a capacity of 1000 litres/hour.	Drewitzweg 12 A-1140 Wien Tel: +43/1/416 85 17 office@1stlevelsolar.com	www.sundrops.at
3F Solar Technologies GmbH	3F Solar Technologies GmbH was founded in August 2012, manufacturing solar hybrid collectors (thermal and electrical) and providing integrated energy system solutions and concepts. Through the direct cooling of photovoltaic cells, 3F collectors can produce more electricity than pure photovoltaic systems. The heat generated is used for hot water and to support heating.	Vorarlberger Allee 38 1230 Wien Tel: +43 1 585 01 78 office@3f-solar.at	www.3f-solar.at
ab&cd innovations GmbH	ab&cd innovations is dedicated to the challenge of developing processes for obtaining chemicals and valuable substances from industrial residue, by-products and biomass. ab&cd innovations works closely with biodiesel producers, the chemistry industry and other industrial companies to process accumulated waste and by-products into high-quality chemicals.	Währinger Straße 42 1090 Wien Tel: +43 650 5116117 office@ABandCD.com	www.abandcd.com
AC-Rädler Umwelttechnik GmbH	AC-Rädler is a producer of the RTC cleaning machine for tube exchangers, for the pipe-saving complete removal of hard coatings and total blockages. The company's main focus is the sale of machines and processes for saving energy and resources in the industrial and heating business, which improve economic efficiency and preserve the environment.	Leonard-Bernstein-Straße 8/2/23.08, A-1220 Wien Tel. +43 (676) 374 65 09 office@ac-raedler.at	www.ac-raedler.at
akaryon GmbH	The company, which was founded in Styria and has also operated in Vienna since 2000, provides in particular web applications in the context of sustainability as well as support with funding applications, concept, implementation and marketing on the web.	Weyringergasse 30B 1040 Wien Tel.: +43 (0)1 5039870 info@akaryon.com	www.akaryon.com
ALLPLAN GmbH	ALLPLAN GmbH was founded in Vienna in 1967 and, since then, has developed from a planning office for heating, cooling and ventilation technology into an international consulting business in building services and energy and environmental management. The company is now active worldwide in the fields of energy and environment.	Hauptsitz Wien Schwindgasse 10 A-1040 Wien Tel: +43 1 505 37 07-0 wien@allplan.at	allplan.at
Architekturbüro Reinberg ZT GmbH	The office has existed as a self-sufficient planning office since 1980, as a civil engineering office since 1985 and as Ziviltechniker GmbH since 2006. This architectural firm deals primarily with ecologically passive buildings and plus-energy buildings. The team has experience in almost all construction areas. More than 100 projects have been realised so far, all of which possess a high ecological standard.	Lindengasse 39/8 1070 Wien Tel: +43 (0)1 524 82 80 architekt@reinberg.net	www.reinberg.net

Organisation	Description	Contact	Website
Atelier Ambrozy	Atelier works with both institutions and private clients. Modern energy-optimised architecture is the focus, while the range of services includes planning and renovation, increased business consulting before and during construction, private construction consulting and lecturing and teaching activities.	Schönburgstraße 7/15 1040 Wien Tel+fax +43 01 5058850 atelier@ambrozy.at	www.ambrozy.at
aWATTar GmbH	aWATTar started operations as an energy supplier to the Austrian market in May 2015. The company chiefly works in energy supply (selling to end users) with an exclusive focus on electricity and the development of software applications that bring their customers special advantages. aWATTar is the first and currently only electricity provider with an hourly variable tariff for end users.	Schottenfeldgasse 15/19 1070 Wien service@awattar.com Tel: +43 01 386 5050	www.awattar.com
BEA Institut für Bioenergie GmbH	BEA offers an ever-increasing range of specialised auditing devices and services for the bioenergy industry, including physicochemical laboratory testing for quality assurance and product development of solid biofuels, consulting and planning services, as well as training sessions. BEA's services are directed at businesses who work in the production and use of energy from solid biomass, especially producers of wood pellets, machine and system manufacturers, the fuel trade and energy service providers.	Avedikstrasse 21 A - 1150 Wien Tel: +43 1 89093 91 office@bioenergy.co.at	www.bioenergy.co.at
crystalsol GmbH	crystalsol deals with the development of a completely new kind of flexible photovoltaic foil. The patented technology combines the advantages of highly-efficient semi-conductor materials with cost-effective reel-to-reel production.	Am Kanal 27 1110 Vienna, Austria Tel: +43 1 890 18 79 office@crystalsol.com	www.crystalsol.com
ETHUS GbmH	ETHUS is a start-up in energy efficiency. In 2015, the company developed the first mobile app for trading energy efficiency measures and successfully launched it on the market. Since 2016, it has also worked with companies from the energy field to implement innovative concepts and solutions for digitalisation of the energy economy, such as making the integration of decentralised production facilities and smart home systems attractive and enjoyable for the user.	Siebenbrunnengasse 17/7 A-1050 Wien Tel: +43 1 9971996 office@ethus.at	www.ethus.at
GRADIENT - process technology GmbH	With its many years of experience, Gradient process technology GmbH possesses considerable know-how as a technological business advisor and planner in a wide range of areas in the processing industry (innovative process technologies, food and biotechnology, energy efficiency).	Pyrkergasse 8/1 A-1190 Wien Tel: +43-1 368 54 33 office@gradient.at	www.gradient.at
GRAT - Gruppe Angepasste Technologie (TU Wien)	Gruppe Angepasste Technologie (Adapted Technology Group - GrAT) is a research centre at the Technische Universität Vienna. The topics of adapted technology, sustainable development and life cycle approach are further developed, demonstrated and conveyed in national and international projects. The concept of overlap is the joint awareness of the responsibility for a socially and environmentally acceptable action with technology and its consequences. In research and demonstration projects, GrAT processes and develops innovations in renewable raw materials, product service systems, sustainable construction, resource and energy efficiency in buildings and technology design and distribution. Its objective is to adapt technologies to human needs and resources and not vice versa.	Technische Universität Wien Wiedner Hauptstr. 8-10 A-1040 Wien Tel: +43 1 58801 49523 contact@grat.at	www.grat.at

Organisation	Description	Contact	Website
HAKOM EDV-Dienstleistungs Ges.m.b.H	Within individual segments of energy data management (EDM), HAKOM is a market leader in Austria and a successful player in Germany and the emerging market. Since 1991, the Viennese company has developed innovative and productive software for the liberalised energy sector. It supports its customers successfully in essential business processes with time series management systems and prognosis solutions.	Lemböckgasse 61/Stiege 2/6 A-1230 Wien Tel: +43 (1) 8157980-112 office@hakom.at	www.hakom.at
has.to.be gmbh	be.ENERGISED is a cloud-based management and invoicing solution from has.to.be gmbh for charging infrastructure for electric vehicles. More than 5,000 charging stations are currently operated using this system. be.ENERGISED represents an easy and interoperable operation of charging stations. Through the integration of mobile direct payment and roaming features, the system does not exclude any electric car user.	Siebensterngasse 31/11, 1070 Wien, Österreich Tel: +43 (0)6452-21200-30 sales@has-to-be.com marketing@has-to-be.com	beenergised.com
Helioz GmbH	The multiple award-winning company Helioz GmbH developed a solar-operated measurement device (WADI), which demonstrates the process of solar water disinfection in a PET bottle. It indicates when the water, disinfected by solar UV rays, is safe to drink. Solar water disinfection (SODIS) is a natural process during which UV radiation from the sun deactivates pathogens in the water and renders contaminated water drinkable again.	Mariahilfer Straße 81/1/15 1060 Vienna Austria Tel: +43 1 585 0004 office@HELIOZ.org	www.helioz.org
Illumination Network Systems GmbH	Illumination Network Systems GmbH offers innovative solutions for efficient and therefore cost-saving management of processes (lighting, transport telemetry, patient surveillance and more). The sensor technology, which is optimised to a low size and minimum power consumption is equipped with highly efficient algorithms for the various applications.	Lastenstraße 19, 1230 Wien Tel: +43 (1) 3000 911-0 info@illuminetsys.com	www.illuminetsys.com
Inercomp GbmH	Inercomp is an independent service company focussing on wholesale energy trading and the energy sector.	Thimiggasse 30, 1180 Wien Tel: +43 1 470 23 22 office@inercomp.com	www.inercomp.com
llynx electronic GmbH	llynx views itself as a competent and reliable partner for the planning, development and manufacturing of your electronics and light controls and sensors. Ilynx products include operational, controlling, and regulation facilities for light and illumination purposes, as well as sensor technology.	Gutheil-Schoder Gasse 8-12 A 1100 Wien Tel: +43 699 13493034 Kontaktformular	www.llynx.at
JIRA ZT &SV GmbH	JIRA ZT & SV GmbH is a civil engineering and expert firm for structural engineering, building physics, acoustics and sound proofing. The team is specialised in building physical planning and the control of small projects through to major projects. Director DI Jira is also a certified thermographer (level 3) and registered energy auditor.	Kanzlei: Springergasse 29 Tür 11 1020 Wien Tel: +43 (664) 5160760 office@jira.at	www.jira.at
Kroneis GmbH Messtechnik für die Umweltmeteorologie	Kroneis GmbH has existed as a manufacturer of meteorological measurement devices, mechanical precision tools and airborne equipment since 1883. In addition to precision device construction, the emerging modern electronics for the development of sensors and measurement systems has also been used. Wind measurement technologies are used, for example, in the wind power industry.	Iglaseegasse 30-32, A-1190 Wien Tel: +43 (0) 1 320 34 92; office@kroneis.at	kroneis.at

Organisation	Description	Contact	Website
Knoth Automation GmbH	KNOTH specialises in the environmentally-friendly cleaning of building components in the cutting process such as motor, steering and gear components. Knoth systems use less energy through their high temperature stability; the energy savings compared to traditional systems amount to between 25 and 60 percent.	Schillingstraße 17 1220 Wien, Austria Tel: +43 1 330 37 38 - 0 office@knoth.net	www.knoth.net
Lukas Lang Building Technologies GmbH	With Lukas Lang Building Technologies, a construction method has been developed to allow buildings to be individually planned and constructed from industrially prefabricated single parts. Constructed buildings can be expanded, changed, or dismantled at any time without lowering their value. This is an efficient construction method for single- and multiple-family homes, estates, nursery schools, hotels, office buildings, staff accommodation, market halls and event buildings, and more. The pioneering 100% industrial manufacturing of building components allows for economical building costs and maximum quality assurance in the production and construction process.	Firmiangasse 7, 1130 Wien Tel.: +43 (0)1 512 60 78-0 E-Mail: office@lukaslang.com	www.lukaslang.com
MetGIS GmbH	MetGIS connects precise weather models and terrain data with ultra-precise forecasts: its customer base includes the energy sector, which relies on precise prognoses for calculating energy production, grid capacity and electricity price development.	Langegasse 16-18 1080 Wien Tel: +43 01/8909032 Office@metgis.com	metgis.at
MyWarm GmbH	myWarm Gmbh is an innovative developer of energy-efficiency solutions for holistic, metrologically controlled and directly verifiable optimisation. The myWarm® | pure-efficiency solution is the first milestone in a development roadmap, which features the goal of use-dependent and self-optimising operation including integrated consumption monitoring for every space.	Heumühlgasse 11 1040 Wien Tel: +43 (0) 1 997 19 21 office@mywarm.at	www.mywarm.at
nonconform zt gmbh	Technically speaking, nonconform is an architectural firm. This means we see it as our primary mission to promote the sustainable development and revitalisation of buildings, public spaces and infrastructure. With our nonconformist ideas workshop and our nonconformist public building, we venture off the beaten track and bring spaces and squares back to life with participative planning, creating flexible urban buildings and sustainable action.	Lederergasse 23/8/EG 1080 Wien Tel: +43 1 9294058 office@nonconform.at	www.nonconform.at
POS architekten ZT gmbh	In line with sustainable architecture, POS Architekten pursue a holistic approach. Competencies and focus points include the planning and realisation of integrated sustainable building concepts. These are designed by our internal planning team and display a high degree of innovation. Through intensive research activity, POS Architekten have developed a high level of expertise in the planning of sustainable buildings and can draw on the latest findings of applied construction research at any time.	Maria Treu Gasse 3/15 1080 Wien Tel +43-1-4095265 office@pos-architecture.com	www.pos-architecture.com
Public Social Responsibility gemeinnützige Gesellschaft mbH	PSR is an independent, non-profit oriented, interdisciplinary research institution with a legal policy and sociological focus and international networking. The institute also supports research plans for the energy sector, including a project on the implementation of a European energy market in the EU.	Annagasse 6 1010 Wien Tel: +43 1 512 09 18 office@psr-institut.at	www.psr-institut.at
Pulswerk GmbH	pulswerk was founded by the Österreichische Ökologie Institut (Austrian Ecology Institute) in 2012. The Ökologie-Institut conducts research towards the sustainable development of our society, while pulswerk advises businesses and politicians in the planning and implementation of sustainable solutions.	Seidengasse 13, 1070 Wien Tel: +43 1 523 61 05-0 office@pulswerk.at	www.pulswerk.at

Organisation	Description	Contact	Website
RATAPLAN-ARCHITEKTUR ZT GMBH	RATAPLAN is the joint office of architects Rudolf Fritz (1961), Susanne Höhndorf (1963), Gerhard Huber (1957), Martina Schöberl (1960) and Friedel Winkler (1958). Their competencies include wall greening, conversions and extensions in the passive building standard, worker participation schemes and much more.	Margaretengasse 20/3 A-1040 WIEN Tel: +43 (0)1 544 06 25 info@rataplan.at	www.rataplan.at
raum & kommunikation GbmH	raum & kommunikation is an interdisciplinary planning office focussing on innovative housing plans, urban development planning and new urban mobility solutions. High social, ecological and economical standards define the actions of raum & kommunikation; here, the person is always the most important aspect of the work. Services consist of many levels; from research and policy consultation and planning on an urban and district level, process mentoring and process control to the implementation of exemplary building projects.	Lerchenfelder Gürtel 43 6/4 A-1160 Wien Tel. +43 1 78 66 559 office@raum-komm.at	www.raum-komm.at
Ressourcen Saving GmbH	The Ecoturbino® is a patented precision piece - a small turbine that saves 36% of hot water through cross-section narrowing and draws in and mixes air (in equal volume to the savings) through a bypass bore hole. The Ecoturbino reduces water and energy consumption.	Alserbachstraße 2 A-1090 Wien Tel: +43 660 7331213 office@ecoturbino.at	ecoturbino.com
Schöberl & Pöll GmbH	Schöberl & Pöll GmbH is a large building physics firm and has made it its mission to promote the most energy-efficiency buildings. The focus of the company lies on building physics planning, research and the further development of the most energy-efficient buildings such as passive buildings, null-energy buildings, plus-energy buildings and energy self-sufficient buildings. Worldwide, the office has supported the highest number of passive building projects, specialises in multi-storey passive building construction and accelerates the development and distribution of plus-energy buildings.	Lassallestraße 2/6-8 A-1020 Wien Tel: +43/1/726 45 66 office@schoeberlpoell.at	schoeberlpoell.at
Seensy	Seensy informs users not only – like other monitoring systems - of their energy consumption, but also supports them in identifying and understanding inefficiencies (=potentials for saving), offers concrete solutions and thus enables savings of up to 50%. Through the merging of various information sources from internal and external contexts in real time, Seensy learns the behavioural pattern of buildings, people, processes and business models, identifies inefficiencies and allows optimum solutions/savings to be achieved with simulations.	InfoTraders e.U. High Tech Campus Vienna Gutheil-Schoder-Gasse 10 1100 Wien office@infotraders.eu	seensy.me
SIROCCO Luft- und Umwelttechnik GmbH	SIROCCO Luft und Umwelttechnik GmbH has been a leading player in the industrial ventilation technology sector for over 100 years. The traditional core business is the production of industrial ventilators and heat exchangers.	Adamovichgasse 3 A-1230 Wien Tel +43 1 604 26 05-0 office@sirocco.at	www.sirocco.at
Solabolic GmbH	SOLABOLIC is developing the next generation of parabolic collectors, which have the potential to significantly increase the economic efficiency of solar thermal power production. Its unique, patented design secures the necessary optical precision in wind and eliminates the inefficiency of large collectors. At the same time, the use of materials, production costs, maintenance costs and delivery costs are reduced.	Inzersdorferstraße 28/23 1100 Wien Tel: +43 1 934 67 28 office@solabolic.om	www.solabolic.com
Spirit Design - Innovation and Brand GmbH	This strategic design company consists of a specialist team in the fields of innovation and brand and develops sustainable solutions for future challenges. Spirit Design advises customers in the fields of mobility, telecommunications/IT, energy, industry and consumers on their future viability and offers a wide range of services. Since 2008, Spirit Design has conducted its own research in sustainable mobility and deals with themes such as alternative drive units, electromobility, intermodality and consistent usability design.	Hasnerstraße 123 1160 Vienna Tel: +43 1 367 79 79-0 spirit@spiritdesign.com	www.spiritdesign.com

Organisation	Description	Contact	Website
Spumix Dämmstoffe GbmH	spumix develops completely new types of insulation materials based on microporous ceramic foam in cooperation with the Technische Universität Wien. The innovative manufacturing process leads to extremely low bulk density together with high resistance. The lint-free and nonorganic products have an excellent heat insulation effect.	spumix Dämmstoffe GmbH Schönlaterngasse 4 A-1010 Wien Tel: +43 676 6014949 E: office@spumix.com	www.spumix.com
Swimsol GmbH	Swimsol GmbH provides planning and installation of photovoltaic systems on roofs. First and foremost, these activities serve to build up competence and prominence in the markets where floating solar systems are offered. The target area is tropical islands and coastal cities, where diesel generators are used for energy production and electricity generation costs are greater than 0.20€ per kWh.	Goldeggasse 2/3 A-1040 Vienna Tel: +43-1-967 2333 office@swimsol.com	swimsol.com
tatwort Nachhaltige Projekte GmbH	The current service portfolio and core competencies of tatwort Nachhaltige Projekte combine communication and participation expertise with content-based technical skills in the fields of renewable energy, environment, water, climate protection, sustainable consumption and the efficient use of resources. The company resolves complex interdisciplinary problems in a cross-sector and innovative way in consortia from economics, science and administration.	Haberlgasse 56/17 1160 Wien T +43 (0)1 409 55 81 tatwort@tatwort.at	www.tatwort.at
tbw research GesmbH	tbw research pools R&D activities from technical areas such as mobility, energy, construction and water management and professionalises the implementation of research and promotion projects.	Schönbrunner Straße 297 Stiege 2, 1120 Wien Tel.: +43 699 171 30 717 office@tbwresearch.org	www.tbwresearch.org
TU Wien **Forschungsschwer-punkt Energy & Environment**	The TU Wien is Austria's largest research and education institution in the natural sciences and technical field, with more than 30,000 students and around 4,800 employees. The research centre "Energy and Environment" was established to promote interdisciplinary cooperation, and it serves to link the existing research initiatives in the building.	Resselgasse 3/1040 Wien Tel. +43 (0)1 58801-406 60 energiewelten@tuwien.ac.at	energiewelten.tuwien.ac.at
UBIMET GmbH	The core competences of UBIMET are in meteorology, particularly in the development and creation of timely and spatially high-resolution weather forecasts, storm warnings and models, as well as preparation of data and prognoses tailored to customers. UBIMET manages the Severe Weather Centre (www.uwz.at), which successfully implemented the concept of weather warning on a natural level for the first time.	ARES Tower Donau-City-Straße 11 A 1220 Wien Tel: +43 1 263 11 22 E: info@ubimet.com	www.ubimet.com
Xylem Technologies	XYLEM Technologies offers businesses, consultants, cities and communities innovative solutions for energy and risk management. Their software solutions such as ECOCITIES, the operator of groups of buildings – such as businesses, communities, cities, property management – support decisions on how budgets can be set in the most efficient way to align the property portfolio with political, economic and ecological goals (e.g.: reduction of costs and CO_2).	Favoritenstraße 16, 1040 Wien Tel: +43 664 86 333 12 support@xylem-technologies.com	www.xylem-technologies.com

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Vienna Business Agency. A service offered by the City of Vienna.
A-1070 Vienna, Mariahilfer Straße 20
wirtschaftsagentur.at

CONTACT: Dr. Lukas Lengauer & Mag. Angelika Sterrer-Tobler, Technology Services
T+43 1 4000-86932, lengauer@wirtschaftsagentur.at T +43 1 4000-86167, sterrer-tobler@wirtschaftsagentur.at

TEXT AND EDITORIAL WORK: Mag. Georg Günsberg, Günsberg Politik- und Strategieberatung
Franz Josefs Kai 27, 1010 Vienna georg@guensberg.at

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