

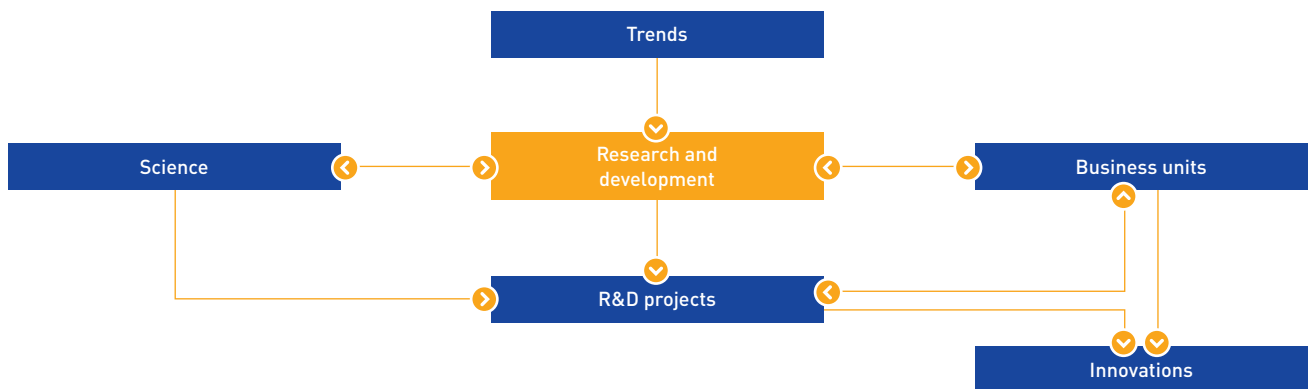
Research, development and innovation

Research and development: Goals, guidelines and processes

The goal of research and development at EnBW is to identify important trends and technological developments at an early stage and to develop the know-how for subsequent commercial utilisation in pilot and demonstration projects. For this purpose, research projects are carried out in collaboration with the operational units at EnBW or with customers – directly at the site of their subsequent application. They form a project

portfolio that is centrally coordinated for all EnBW units. This ensures that successful research projects deliver innovations for EnBW. The research and development activities are integrated into an external and internal network of partners. Research, development and innovation also leads in many cases to inventions and patents. The portfolio of patents grew by nine patents (previous year: eight) in 2017; the EnBW Group held 183 patents (previous year: 174) at the end of the year. The patents held by EnBW focus mainly on the areas of smart solutions and electromobility.

The research process at EnBW



Research and development: Key points and selected results

Research and development at EnBW focuses on renewable energies and storage systems for the smart digital energy world.

Renewable Energies

Photovoltaics: The University of Stuttgart has developed a new laser process that enables the inexpensive production of non-toxic silicon solar cells with a high level of efficiency. Since August 2017, EnBW has been participating in a government-funded research project at the university that now aims to bring the laser-based process for linking these cells together to form modules to maturity. As part of these activities, the EnBW subsidiary EnPV was founded in December 2017. If the project is successful, EnPV will form the nucleus of the future marketing of this patented production process.

Weather forecasts: Energy supply companies are increasingly dependent on wind and sunshine forecasts due to the ongoing expansion of renewable energies. Weather forecasts for the energy trade have only been available for a standard period of around 14 days up to now. Against this background, the European Union approved a project in July 2017 that aims to improve the quality of forecasts that are made for a period of several months. Twelve European weather institutes and companies – including EnBW as the only German energy company – are working together on the project. The first results are due by the end of 2018.


Soultz-sous-Forêts geothermal power plant: The partners Electricité de Strasbourg and EnBW jointly operate the Soultz-sous-Forêts geothermal power plant in the Alsace region of France that uses a natural geothermal reservoir lying at a depth of 5,000 metres. The electrical output of the power plant is 1.7 MW. Following the end of research operation, the commercial generation of geothermal electricity started in autumn 2016. In 2017, the power plant generated 7.7 GWh of electricity with an availability of 90% (7,900 operating hours).

Bruchsal geothermal power plant: EnBW has operated the Bruchsal geothermal power plant together with Energie- und Wasserversorgung Bruchsal GmbH since 2009. The demonstration plant generates electricity with a nominal output of 0.5 MW using 120 degree hot thermal water pumped from a depth of 2,500 metres. The plant achieved 2,100 operating hours in 2017. The replacement of a connecting pipeline between the power plant and the borehole was brought forward after there were a number of leaks. The power plant can commence operating again in the spring. From autumn 2018, the power plant will not only generate electricity but also provide a public facility in the local vicinity with heating. The supply contract was concluded in December 2017. EnBW is thus expanding its geothermal expertise to include the supply of heating to customers.

Storage systems for the smart digital energy world

Electromobility: As part of the “SLAM – Quick-Charging Network for Road Axes and Metropolises” research project funded by the German Federal Ministry for Economic Affairs and Energy, a total of 68 quick-charging stations was installed by EnBW at 34 motorway service stations across Germany by the start of 2017. Business models for the operation of quick-charging stations with very high charging outputs were developed in the SLAM project. The cooperation with Germany’s largest service station operator Autobahn Tank & Rast GmbH is an important component for the implementation of the e-mobility strategy at EnBW, which aims to make it possible for customers to quickly and easily charge their electric cars everywhere. EnBW installed a quick-charging station at each of an additional 117 locations operated by Autobahn Tank & Rast GmbH by the end of 2017, 80 of which with the help of funding from the Federal Ministry of Transport. Technical improvements were made in 2017 to the charging network installed in Stuttgart with the help of state funding and it is now even more user friendly. New developments in the area of parking space sensors and value added services were initiated and will be field tested in 2018.


EnBW is investigating how green electricity can be used to cover regional demands to a greater extent than ever before with the help of storage systems in a variety of research projects:

Storage systems for commercial customers: In 2017, EnBW cooperated with the storage system supplier ads-tec, the solar experts from Pohlen Solar and the retail company Aldi Süd to find out how the discount store could use even more self-generated solar electricity in their branches. Photovoltaic power plants fitted to the roofs of more than 1,200 branches generated climate-friendly solar electricity, of which around 80% was used for the company’s own consumption. The solar power plants have now been combined with a battery storage system at three branches in the Frankfurt am Main region to create a  virtual power plant. EnBW was responsible for energy management and used a self-developed algorithm to

continuously evaluate whether it was more beneficial for Aldi Süd to directly consume the solar electricity, store it or make it available on the energy market. In this practical test, EnBW was able to demonstrate the great potential offered by solar power plants and storage systems when they are combined to form a virtual power plant.

Storage systems for household customers: In autumn 2016, three household customers were fitted with storage systems in order to develop a smart control system that can adapt to the availability of electricity on the grid and postpone the times electricity is drawn from the grid without any loss in comfort. In the 2017 measurement phase, EnBW determined how to manage the household storage system to the benefit of the customer so they are able to make use of any electricity surpluses on the regional grid.

Power plant storage systems: Cross-sector considerations on how storage systems can provide added value led to a cooperation with Bosch to develop battery solutions for the energy market. A large 5 MW battery was installed at the Heilbronn coal power plant in November that will enable the plant to respond even better to fluctuating decentralised feed-ins from spring 2018. EnBW is responsible for the marketing of the stored energy in this joint venture.

Power to x: EnBW has been researching the possibilities for generating and storing climate-friendly energy sources such as biogas and hydrogen from green electricity ( sector coupling) since 2011, with funding from, amongst others, the German government. The projects have revealed the conditions necessary to already make synthetic fuels economically viable today. EnBW gained experience in the storage of green electricity and the use of hydrogen in the transport sector, for example, with a hydrogen filling station in both Stuttgart and Karlsruhe. Following the end of the project in 2016, EnBW is continuing to supply the hydrogen buses operated by Stuttgarter Straßenbahn AG at the bus extension to the Stuttgart filling station that was built with state funding. In another project, the EnBW subsidiary ZEAG is generating hydrogen from green electricity sourced from the nearby “Harthäuser Wald” wind farm, also with the help of state funding, and is supplying it to the rocket test rig at the German Aerospace Center (DLR) in nearby Lampoldshausen.

In the Biohybrid project, the EnBW subsidiary Erdgas Südwest has developed a concept to make biogas with the quality of natural gas available everywhere where customers may require electricity and heating. This also includes providing bio-liquefied natural gas for the transport sector, the market for which is starting to emerge. The first biohybrid plant is due to be constructed in Ostrach in the Sigmaringen region in 2018. Energiedienst Holding (ED) also intends to build a plant for synthetic liquid fuel (power to liquid) in 2018. One of the fundamental substances required is hydrogen, which will be generated using hydropower. The ED power-to-gas plant in Wyhlen is under construction and should be placed into operation by the end of 2018.

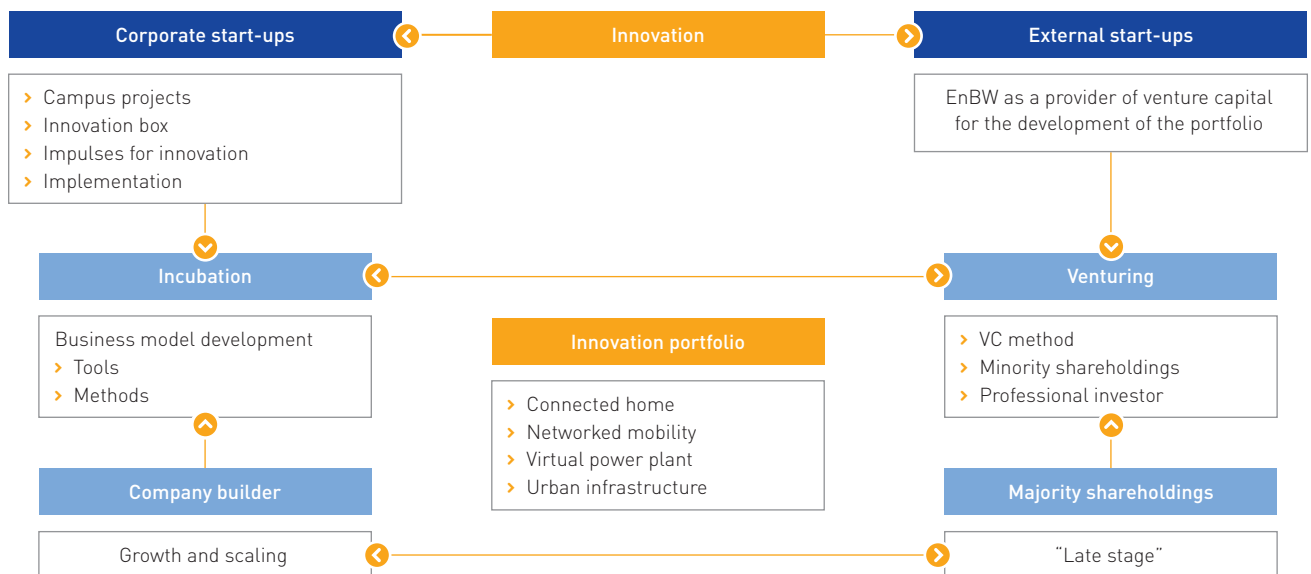
Innovation management: Goals, guidelines and processes

EnBW develops new business models outside of its core business with the central innovation management system in order to quickly identify new sources of revenue for the Group and bring them to the market. The development of new skills and work processes plays a major role. An agile innovation culture has been established at EnBW in this way – supported by selected partnerships and participating interests in start-up companies. The innovation strategy focuses on two main approaches: the internal generation and scaling up of new business models in corporate start-ups and investments in external start-ups by EnBW New Ventures GmbH. In the internal generation of new business ideas, innovation management has developed a new framework in the form of the Company Builder that provides additional skills to support the scaling up of corporate start-ups after they are launched onto the market. The Company Builder provides the start-ups

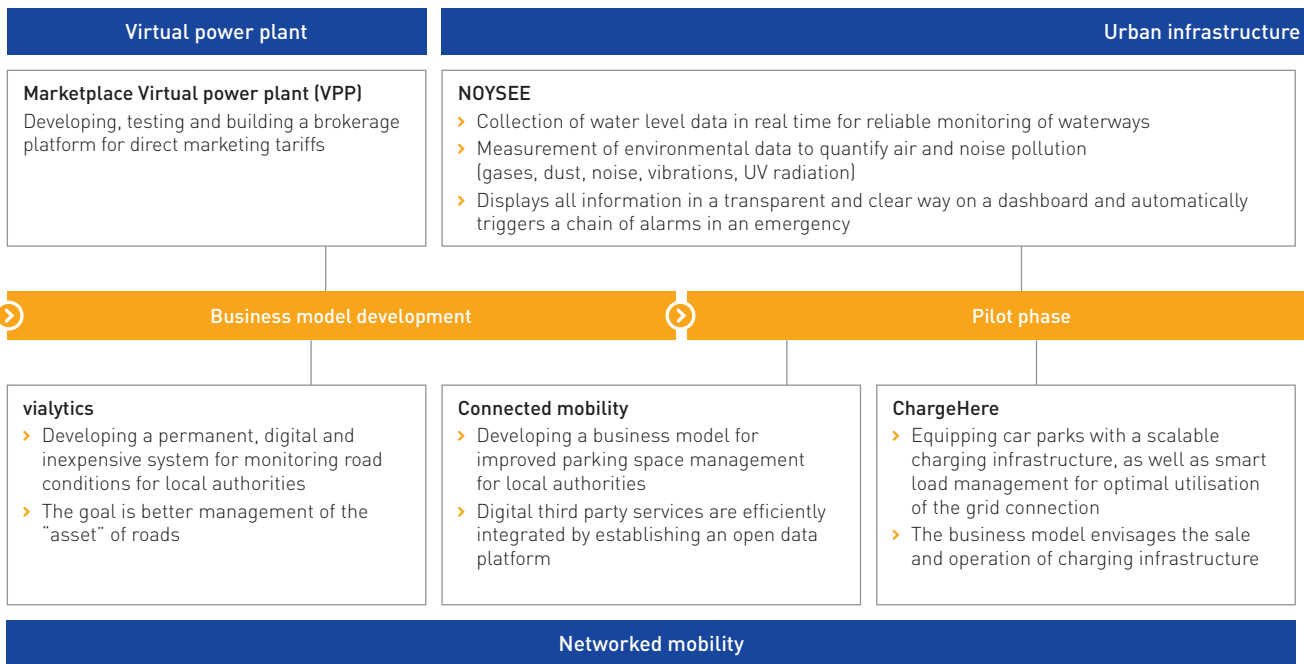
with experts from controlling, sales and marketing so that they can optimise their products and establish them on the market. Above all, it supports the start-ups in the expansion of existing sales channels and the development of new ones.

EnBW New Ventures invests in start-ups that are pushing forward the converging markets for energy, mobility and urban living. It focuses on entrepreneurial teams who realise value added for their customers using scalable business models and new technologies. The aim is to use the total available investment volume of €100 million to secure minority shareholdings of between 10% and 30% in up to 20 start-ups. EnBW New Ventures plays the role of an active investor here: it supports the start-ups as a sparring partner and is represented on their boards. Via EnBW New Ventures, the start-ups receive access to professional investor expertise and a customer and supplier network on the energy market. In addition, commercial cooperation with the operative units at EnBW is also possible.

The innovation process at EnBW



Current projects at the EnBW Innovation Campus



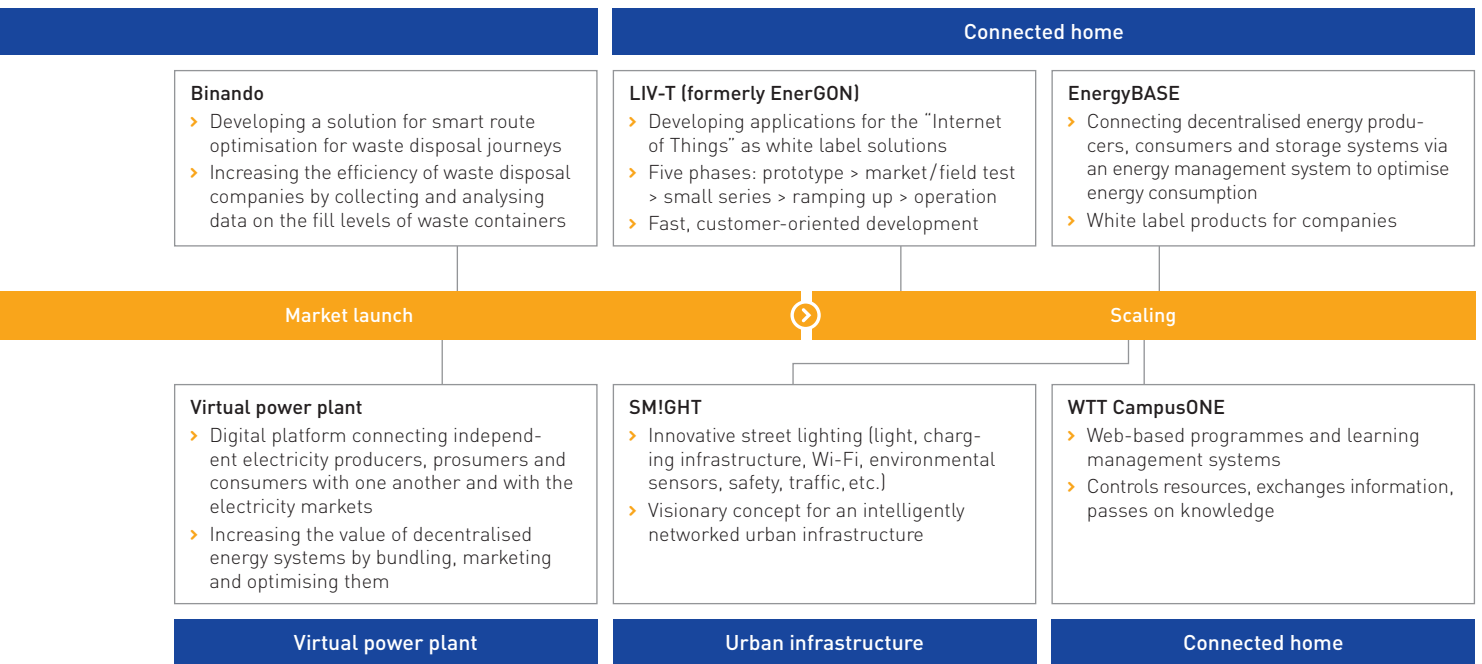
Innovation: Key points and selected results

1492@EnBW: In 2013, the concept 1492@EnBW was brought to life by human resources and innovation management. It is designed to take up business ideas that cannot be developed in normal operations so that they can be independently developed by Group-wide, interdisciplinary teams. If successfully developed, the projects are transferred back to the corresponding business unit or to the EnBW Innovation Campus to take them through to market maturity. The kick-off event for the fifth 1492@EnBW season was held at the Innovation Campus on 15 November 2017. In the previous four seasons, which usually run for four to six months, a total of 16 business ideas were developed.

External accelerator programme ACTIVATR: After participating in 2016, EnBW took part in this programme with interdisciplinary external teams for the second time in 2017. The aim of the programme is to take ideas for new business models through to market maturity and found start-ups. One successful example is the start-up Binando, which aims to make waste management innovative and digital. As part of the smart city strategy in cooperation with EnBW, the fill level of waste containers can be detected so that they can be emptied at the right time. This enables waste management companies to work up to 40% more efficiently. The vialytics project is currently developing the business model "smart sensors for better roads" for the management of road

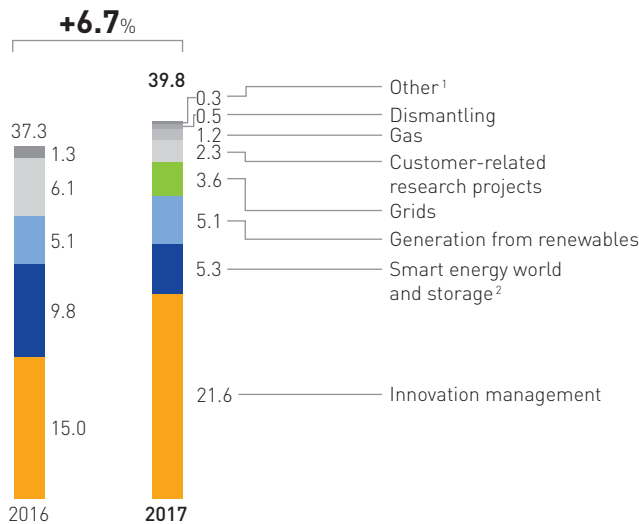
maintenance. It comprises a complete digital solution for continuously and automatically monitoring the quality of roads for local authorities. The project grew out of the last ACTIVATR programme and is being supported by EnBW.

Spin-off of LIV-T: The EnerGON (today LIV-T) project was started at the Innovation Campus almost two years ago. After the first spin-off company WTT CampusONE GmbH was formed on 1 January 2017, a second independent company was formed by innovation management with effect from 1 October 2017. The new company based in Munich is called LIV-T GmbH and develops data-based Internet-of-things (IoT) products that allow the energy infrastructure in buildings to be smartly networked. Alongside EnBW as the majority shareholder, company builder Mantro GmbH from Munich is also participating in this joint venture. In cooperation with Mantro, two products have already been developed and launched on the market: Oilfox is an intelligent fill-level sensor for oil tanks. The oil level can be read using the associated app at any time and more oil can be ordered directly. Oilfox is being distributed throughout Germany by BayWa AG and the trading company Mobene GmbH & Co. KG. Many thousands of units have been sold since March 2017. The heating and air conditioning system Raumgold automatically detects whether a room is being used or not and adjusts the temperature accordingly. The system consists of a central unit with various different sensors and is used above all in public buildings such as schools. Local authorities were able to reduce their energy costs by 18% on average using Raumgold.



Expenditure and personnel

Expenditure on research, development and innovation in € million



1 Also includes conventional generation.
 2 Includes, e.g. electromobility and hydrogen.

The EnBW Group spent €39.8 million (previous year: €37.3 million) on research, development and innovation in the 2017 financial year. The Group received government research grants of €2.9 million (previous year: €3.8 million). A total of 61 staff (previous year: 38) were employed in the areas of research, development and innovation in 2017. The increase in expenditure and personnel is due to the expansion of the group of consolidated companies. A further 105 employees (previous year: 72) were involved in innovation projects. 193 employees (previous year: 155 employees) were involved in research and development projects as part of their operational work.

The main points of focus of the research and development activities in the grids sector were the integration of electromobility, smart electricity grids and the application of sustainable operating materials. Innovation projects mainly focussed on the theme of digitalising grid and customer processes.