Designetz: A modular concept for the energy transition – from isolated solutions to an efficient energy system of the future

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ABSTRACT

While the rapid upturn in renewable energy sources (RES) opens up significant ecological, economic and social opportunities, the trend is presenting the energy sector as a whole with some major challenges. These stem from an energy generation structure that is becoming more and more decentralised and from the associated complexity involved in planning and operating the energy networks. Securing the energy supply in line with the objectives of the energy transition (decentralisation, decarbonisation and the interconnection of consumption and generation using information technologies) requires solutions that combine supply-dependent generation with flexibility in relation to load and storage, and that implement the integration of the renewable energy sources. To do this, individual solutions and new concepts will need to be systematically observed and linked to demonstrate the development of a pioneering complete system. The Federal Ministry for Economics and Energy (BMWi) funded project Designetz will lay out the roadmap from single solutions to an efficient energy system of the future – under the motto: The energy transition starts and ends with the citizens.

INTRODUCTION

Germany – and other countries as well – are making a fundamental shift in how they meet their energy needs. This is being driven by the finite supply of fossil fuels, global warming and the country's phasing out of nuclear power, which has already been set in motion. The shift towards renewable power as part of the energy transition and the unprecedented expansion of capacity in this area over the past years is already having a major economic, environmental and social impact and will continue to do so. The German government is seeking to increase the share of renewables as a percentage of gross electricity consumption from roughly 32 per cent at present to at least 80 per cent by 2050. For the energy transition to succeed, a number of challenges stemming from a renewables-based energy generation structure and the associated demand placed on power grids need to be overcome in the next few years. Securing the future energy supply in line with the energy transition objectives requires a major investment in grid and storage capacity and solutions that combine intermittent generation with flexibility that stems from either load or storage, and that implement the integration of the renewable energy sources. To do this, the energy system must be reflected upon holistically, at all levels and across all participants and energy sources: from generation to storage, transportation and distribution to consumption. The key cogs in a future, intelligent energy system are information and communication technologies (ICT) as well as the interaction between smart grids and increasingly smart energy markets.

DESIGNETZ TACKLES THE CHALLENGES PRESENTED BY THE GERMAN ENERGY TRANSITION

The Designetz showcase covers North Rhine-Westphalia, Rhineland-Palatinate and Saarland. A region that already today meets the conditions set out for a 2035 energy transition scenario on a local level, i.e. intermittent generation provides up to 100% (and even more) of the energy consumed locally at least part of the time. One major aim of the Designetz endeavour is to illustrate how to deliver a secure energy supply in such an environment. In the future, near-zero CO_2 emissions have to be integrated at minimum cost in a socially acceptable manner and present concepts and technologies that can be used on a mass scale to achieve this objective. The showcase region, displayed in figure 1, in which 22 million citizens have their residence, is likewise a model region for Germany, capable of providing information that is relevant nation-wide and serving as a blueprint for the country as a whole. In this way, Designetz is able to exemplify an approach to sustainably and cost effectively performing future supply tasks under real-life conditions comparable to those to be found in other regions.

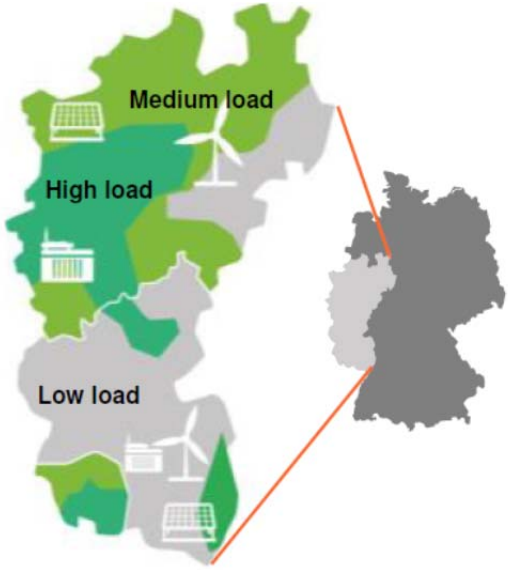

Figure 1: The Designetz region (North Rhine-Westphalia, Rhineland-Palatinate and Saarland), can serve as a blueprint for the country as a whole

A paradigm shift

The basic approach taken in achieving the Designetz' goals involves the efficient use of the flexibility the system has to offer as a means to overcoming challenges, including excess power generation and congestion or bottlenecks in the grid. In this approach, a new kind of hierarchical system responsibility is implemented on the basis of a cascading, bidirectional system. As part of the implementation process, a (communication) concept and data system are defined across all network levels and for all market participants. This allows flexibility to be effectively identified, enables its future marketing and coordinated use and ensures system stability, making it possible to resolve issues like grid congestion on a local (in energy cell(s)), regional (in energy zones) and national level in the process.

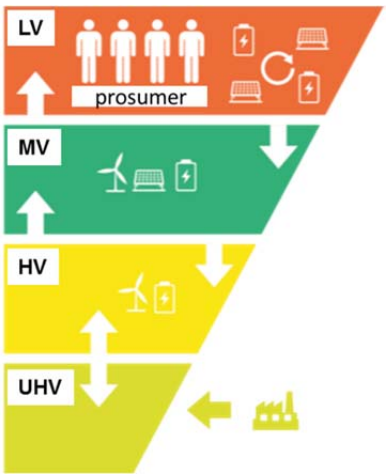

Figure 2: Paradigm shift – The energy system will be designed bottom up

As illustrated in figure 2, the energy system is thus structured bottom up and involves a decentral control concept, i.e. instead of implementing one single central control authority a decentral and subsidiary approach to control is being implemented. In this more and more decentral system, the increasing number of prosumers is enabled to trade energy and flexibility amongst themselves. Higher voltage levels are not involved unless e.g. an LV network area is no longer able to meet all necessary needs with the flexibility available within its realm.

DESIGNETZ ENBABLES MULTI-PORT INTERACTION

To facilitate such a cascaded, bottom-up approach, a modular ICT system and an integrated data and service platform are designed to be both scalable and technology-neutral. This is done to allow existing research projects in within the Designetz area and new technological strategies to be integrated in keeping with the spirit of a 'showcase'. The key cogs in a future, intelligent energy system are information and communication technologies (ICT) and a matching telecommunications infrastructure (inter alia LTE450) and smart metering solutions according to German law, i.e. gateway administration) that make it at all possible for smart grids and their operators to interact with the energy markets. The single demonstration projects involved in the overall Designetz approach can utilise the data thus provided to develop customised business models. An integrated data security and data privacy concept is required to safeguard the interests of all participants involved and protect against cyberattacks. These considerations must be taken into account during all phases in the development process ('by design').

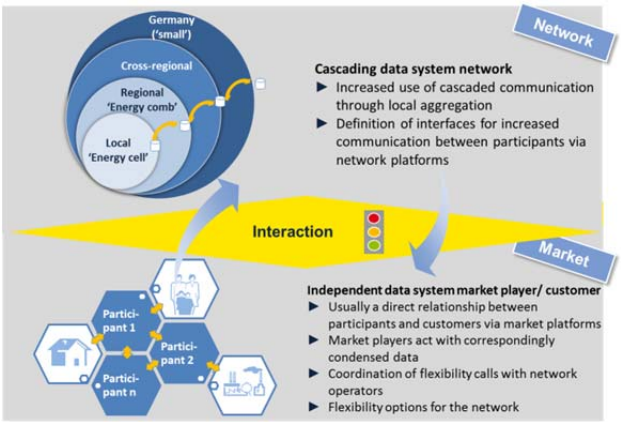

Figure 3: Interaction between the grid and market

Figure 3 illustrates the Designetz approach: Interaction of the market and grid involving all actors and across all levels is facilitated via independent data systems.
In addition to providing and testing ICT systems and

data/service platforms, a series of innovative technical upgrades that act to increase flexibility are implemented in steps in the infrastructure and architecture of the various demonstration projects. In combination with proven state-of-the-art systems and innovative technology concepts, the aim is to unlock additional flexibility by integrating market and grid via an IT gateway.

System cockpit and energy gateway

The Designetz approach at its core entails integrating grid and market demonstration projects and establishing targeted interaction between these two realms (grid and market) while respecting unbundling rules in the form of a system cockpit. The system cockpit, as illustrated in figure 4, serves as a tool that provides a system-wide view of future supply tasks in Germany within the scope of the project. It facilitates real-time simulation of demand for flexibility and their physical order. The Designetz system cockpit is thus as a showcase for the whole system in itself: The development and demonstration of technical and process-related solutions for intelligent market structures for leveraging flexibility potential. The system cockpit will also serve as the link between real data and computational analyses and, as a result, will provide recommendations for action with regards to so-called regional data nodes (RDN) for the demonstration projects. RDNs are designed and implemented to transfer flexibility and share measurement data between the participants and demonstration projects. Specific future challenges are derived on the basis of the visualisations, and future products for the market are identified and tested.

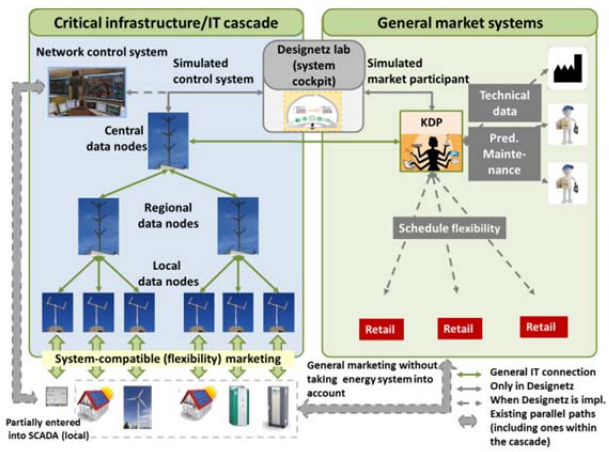

Figure 4: Overall Designetz configuration

Demonstration sites

The Designetz project involves approx. 30 single demonstration projects (existing ones as well as new ones which will be set up in the next years) which include many different technologies and approaches from various Power-to-X solutions to designing and building the "substation of the future". Together the so-called "demo sites", which illustrates figure 5, provide an integrated test environment. Technical solutions should illustrate how decentralised energy can be used to supply existing load centres with minimum overall economic costs. In pursuing the goal of efficient infrastructure utilisation, the practicality of balancing the supply and demand for renewable energy on a regional basis is being explored. How these measures are received by the public and users directly concerned is a key factor when developing the concepts. In order to ensure a socially preferable result Designetz will explore the complicated and highly dependent interaction between market driven flexibility as well as system and network friendly flexibility against the folio of the necessary ICT infrastructure which is the major „enabler" for any new services.

The following demonstration projects are being set up or integrated as existing projects into Designetz:

- Grid4EU
- Das proaktive Verteilnetz
- Smart Country
- Smart Operator
- WiLT (weather dependent indirect line monitoring)
- HTLS (High Temperatur Low Sag)
- PtG Ibbenbüren
- ElChe Wettringen

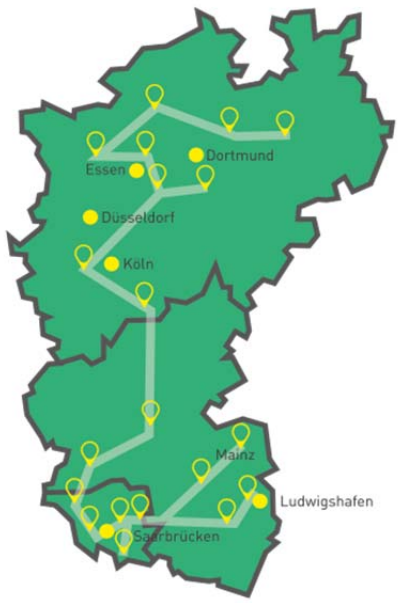

Figure 5: Demonstration sites on the 'Energy road'

The demonstration projects are being presented to the wider public on the Designetz' 'Energy road', true to the motto: The energy transition starts and ends with the citizens.

DESIGNETZ COMBINES EXPERTISE FROM LEADING COMPANIES AND ACADEMIC INSTITUTES

The broad range of technical and scientific work objectives being pursued as part of Designetz, along with the many innovations stemming from the project, will require that partners from the field of science and industry, as well as the energy and ICT sectors, work together to create common solutions for the energy transition. Participants from across all relevant fields in the energy sector and beyond correspondingly collaborate in Designetz to demonstrate a systematically comprehensive observation of the synergy of increased flexibility requirements for covering changing demand and the provision of system services across network levels and regions.

One of the key challenges of the energy transition is providing communication and linking all participants. The partners involved on the ground in Saarbrücken will be providing security and data privacy expertise from one of three cyber security centres in Germany. A total of 15 associated institutes and 31 project partners are taking part in Designetz. 22 companies from the energy sector, seven from industry, three from the ICT sector, and 14 scientific institutions are partners in the project. Figure 6 lists the project and associated partners involved in Designetz.

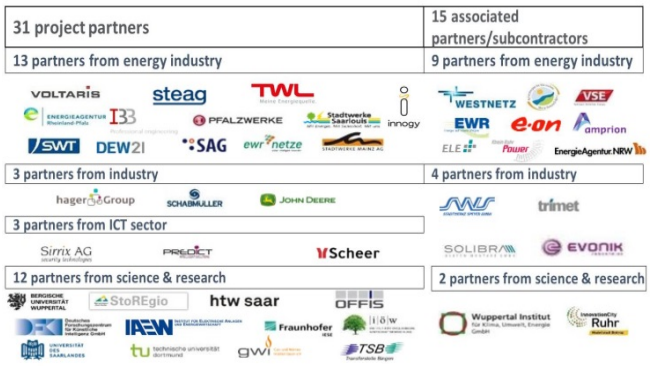

Figure 6: Designetz Partners

Associated partners provide specific contributions at a work package and demonstration project level within the scope of the project without submitting their own request for funding. They are integrated directly into the relevant work packages or demonstration projects via the partners.

The project partners pool their expertise and past experience to attain the goals and achieve innovation in the selected fields set out for the showcase project. This includes many years of experience gained on the market and in (public and funded) research and development projects and various types of expertise acquired in the process.

DESIGNETZ IS PART OF A GERMAN RESEARCH STRATEGY

The project is part of the 'Smart Energy Showcases – Digital Agenda for the Energy Transition' (SINTEG) funding programme of the Federal Ministry for Economics and Energy (BMWi); see figures 7+8. Innogy, its major DSO subsidiary Westnetz and 44 other partners are involved in Designetz. The Designetz project has a total volume of around €66 million, with granted funding of roughly €30 million. The project started in January 2017 and will run for four years. Preliminary results will be published at the CIRED 2019.

Other SINTEG projects include WINDNODE and NEW 4.0 as well as C/sells and enera. While the first two are located in areas in which wind is the major RES production, c/sells focuses on PV mostly. As enera Designetz comprises regions that are mostly driven by wind and/or PV. In difference to enera the Designetz project area also includes major load centres, e.g. the Rhine-Ruhr area and the industrial centres in and around Saarbrücken as well as Ludwigshafen (cf. the green and dark green areas in figure 1).

Figure 7: The SINTEG approach

Bundesministerium für Wirtschaft und Energie

Figure 8: Designetz sponsor