Transforming the Energy System in Germany – About the Role of the Surveyor in Dealing with Climate Change

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Key words: Adaptation, Climate Change, Energy Transition, Geodesy, Geoinformatics, Governance, Land Management, Mitigation, Public Participation, Surveyor.

SUMMARY

Climate change is happening now, worldwide and in Germany, too. The article describes existing knowledge on climate change in Germany and explains the Federal Government's current energy policy. As a response to the nuclear disaster in Fukushima, in 2011 Germany adopted decisions on the gradual phase-out of nuclear power and on accelerating the energy transformation. The new energy concept sets ambitious goals for the expansion of renewable energy, increased energy efficiency and less greenhouse gas.

With this article the author identifies a wide range of climate change mitigation and adaptation strategies in which the surveyor is involved. The surveyor can play a significant role, establishing, quantifying, and managing climate change. With his specialized skills in the broad fields of geodesy, he can substantially contribute to helping mitigate and adapt climate change and to reduce climate-related risk. Requirements are not only engineering know-how but also the surveyors' variety of skills and knowledge in geoinformatics, land management and development, building and land law, real estate and business administration as well as social competence.

Note: The article is inspired by the Policy Paper "Geodesists and the Energy Turnaround", formed by the three German geodetic associations DVW, BDVI and VDV in October 2013. In his function as chair of the DVW research group "land management", the author has played a significant role in the development of the paper.

ZUSAMMENFASSUNG

Die Regierung der Bundesrepublik Deutschland hat im Jahr 2011 den Ausstieg aus der Kernenergie beschlossen. Das Energiekonzept setzt ehrgeizige Ziele für den Ausbau erneuerbarer Energien, mehr Energieeffizienz und weniger Treibhausgase. Die Energiewende ist ein gesellschaftliches Megathema und stellt auch für Ingenieure und Geodäten eine besondere Herausforderung dar.

Der Autor zeigt mit diesem Aufsatz den Beitrag der Geodäten zur Energiewende in den Handlungsfeldern der Geodäsie, der Geoinformation und des Landmanagements auf. Er stellt die breite Angebotspalette geodätischer Expertise bei der Gestaltung der Energiewende vor. Geodäten liefern mit ihren fachübergreifenden Kompetenzen Lösungsansätze zur erfolgreichen Umsetzung der Energiewende, indem sie z.B. raumbezogene Informationen

beim Netzausbau zur Energieversorgung erfassen und analysieren, mit Hilfe von moderner Satellitentechnologie Veränderungen der Erde im Zuge der Klimaforschung beobachten oder die Instrumente des Landmanagements in Energiewendeprojekten aufzeigen.

Anmerkung: Der vorliegende Artikel stellt eine überarbeitete Fassung des Positionspapiers "Die Geodäten und die Energiewende" dar, dass von der Interessengemeinschaft Geodäsie der drei Verbände BDVI e.V., DVW e.V. und VDV e.V. erstmals im Oktober 2013 auf der Intergeo in Essen/Deutschland der Öffentlichkeit vorgestellt wurde. Als Leiter des DVW-Arbeitskreises 5 „Landmanagement" hat der Autor dieses Aufsatzes hieran wesentlich mitgewirkt.

Transforming the Energy System in Germany – About the Role of the Surveyor in Dealing with Climate Change

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1. IMPACTS AND VULNERABILITIES – CLIMATE CHANGE IN GERMANY

The climate is changing. Over the past 100 years, the Earth has become a warmer place. Since the beginning of the 20th century, the global mean annual temperature has risen by 0.85 degrees Celsius (°C). The Intergovernmental Panel on Climate Change (IPCC) says there is a "very high probability" that this is due to human activities (IPCC 2013). If people continue to emit climate-relevant gases into the atmosphere without any restrictions, scientists expect mean temperatures to rise by 1.5 degrees Celsius (°C) relative to 1850 to 1900 by the end of the century (all RCP scenarios except RCP 2.6, RCP = Representative Concentration Pathways).

In Germany, mean annual temperatures have risen by nearly 0.9 degrees Celsius (°C) since 1901, in the Alps; the temperature increase is almost 1.5 °C due to the reduced snow cover and other feedback effects. From 1990 to 1999 meteorologists recorded the warmest decade of the entire 20th century. Furthermore, they have found that precipitation has increased by about nine percent since the beginning of the 20th century (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2009, 14).

Separated by regions, the highest vulnerability to climate change is exhibited by Southwest Germany, the central parts of Eastern Germany, and the Alps. In Southwest Germany (upper Rhine rift) especially the high temperatures and floods cause problems. Furthermore, agriculture and forestry are highly vulnerable to rapid warming and increased risk of extreme weather conditions. In Eastern Germany there is a high vulnerability with respect to flooding in the large river basins of the Elbe and Oder. The Alps are showing above-average to climate changes: Decrease in the number of ice and frost days; greater warming of winter than summer temperatures; precipitation falls as rain rather than snow; less summer and more winter precipitation; earlier onset of snowmelt with a resultant shift in maximum runoff from spring to winter.

One of the latest natural catastrophes in Europe was the flooding in Southern and Eastern Germany and the neighboring states in May and June 2013, which gave rise to an overall loss of more than €12bn (US$ 16bn) and an insured loss in the region of €3bn plus (US$ 3.9bn). By way of comparison, the Elbe flooding in 2002 as the costliest natural disaster ever in Germany caused an overall economic loss of US$ 16.5bn, of which US$ 3.4bn was insured (Munich Re Press Release 9 July 2013).

To contribute to a more sustainable and effective disaster risk management, International Federation of Surveyors (FIG) implemented a Task Force on Surveyors and the Climate Change to highlight the current and future need for research and action in the field of climate change governance, adaptation and mitigation.

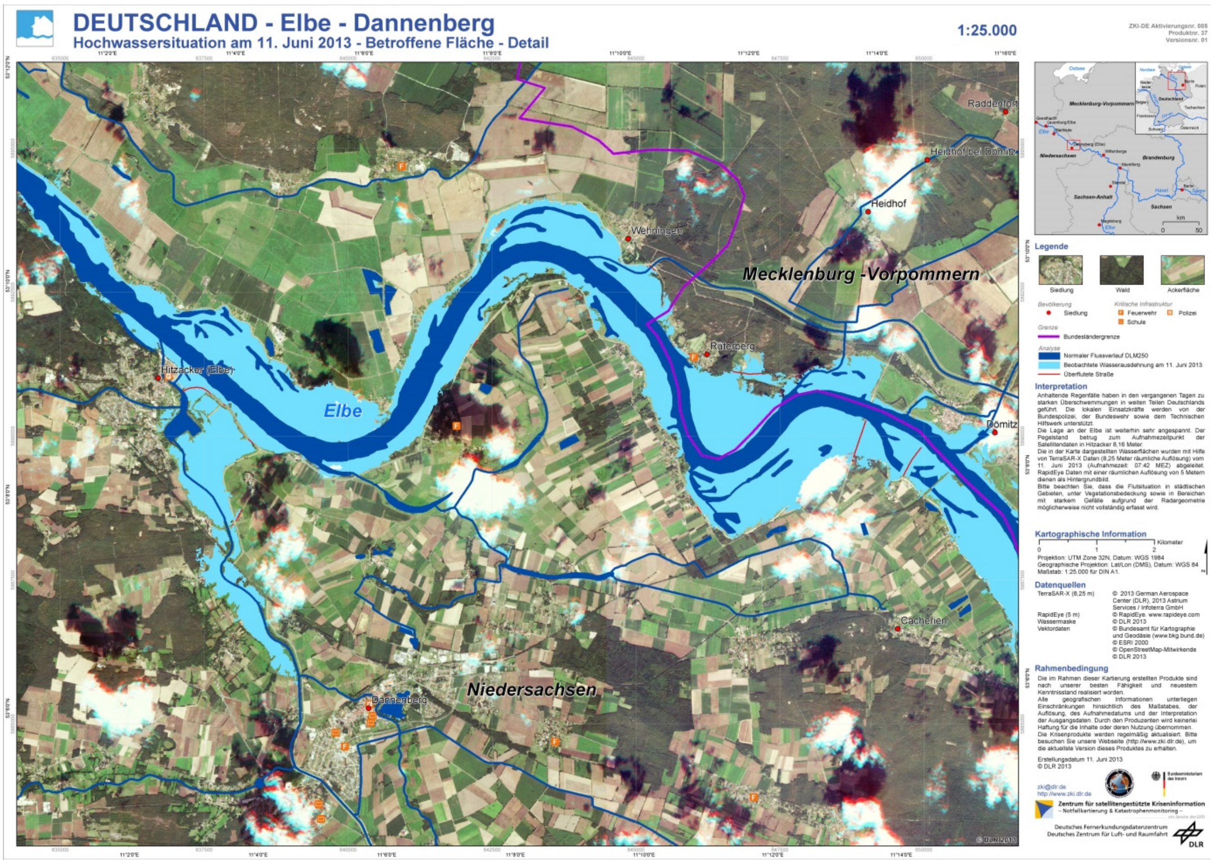

Figure 1: Flooding in Dannenberg on the river Elbe, 11 June 2013, Copyright: ZKI/DLR.

2. GERMANY'S CLIMATE POLICY

Securing a reliable, economically viable and environmentally sound energy supply is one of the great challenges of Germany's climate change policy. A core element of this is the implementation of political objectives for the future energy system: In September 2010 the Federal Government of Germany adopted an energy concept which sets out Germany's energy policy until 2050 and specifically lays down measures for the development of renewable energy sources, power grids and energy efficiency (Federal Ministry of Economics and Technology 2010).

Against the background of the nuclear meltdown at Fukushima/Japan in March 2011, the role assigned to nuclear power in the energy concept was reassessed and eight old nuclear power plants were shut down permanently. Furthermore, a decision was taken to phase out operation of the remaining nine nuclear power plants by 2022. In June 2011 the Federal Government adopted the energy package which supplements the measures of the energy concept and speeds up its implementation (Federal Ministry of Economics and Technology, Nature Conservation and Nuclear Safety 2012).

In line with the coalition agreement, greenhouse gas emissions are to be cut by 40% by 2020, and by at least 80% by 2050, with 1990 being the base year for both measurements (see figure 2 on the next page).

Renewable energies currently account for around 12 % of total energy consumption in Germany (Federal Ministry of Economics and Technology, Nature Conservation and Nuclear Safety 2012, 9). By 2020 renewable energies are to account for 18 % of gross final energy consumption. After that, the German government will seek to make renewable energies account for the following proportion of gross final energy consumption: 30 % by 2030, 45 % by 2040 and 60 % by 2050.

In electricity consumption, renewable energy sources already reached a 23.5 % share in 2012 – three times higher than ten years ago (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2013, 5). By 2020 electricity generated from renewables is to account for 35 % of gross electricity consumption. Following this, the German government will seek to increase the proportion of gross electricity consumption contributed by electricity from renewable energy sources to 80 % by 2050.

By 2020 primary energy consumption is to be 20 % lower than in 2008, and 50 % lower by 2050. This calls for an annual average gain in energy productivity of 2.1 %, based on final energy consumption. Compared with 2008, the Federal Government seek to cut electricity consumption by around 10 % by 2020 and 25 % by 2050. The building renovation rate will need to double from the current figure of less than 1 % a year to 2 % of the total building stock. In the transport sector, final energy consumption is to fall by about 10 % by 2020 and by about 40 % by 2050, the baseline in this case being 2005.

	year 2020	**year 2030**	**year 2040**	**year 2050**
Reduction in greenhouse gas emissions (base year: 1990)	- 40 %	- 55 %	- 70 %	- 80 %
Share of renewable energies in total final energy consumption	18 %	30 %	45 %	60 %
Share of renewable energies in electricity consumption	35 %	50 %	65 %	80 %
Reduction of primary energy consumption (base year: 2008)	- 20 %			- 50 %
Reduction of electricity consumption (base year: 2008)	- 10 %			- 25 %
Reduction of final energy consumption in the transport sector (base year: 2008)	- 10 %			- 40 %

Figure 2: Germany's Energy Concept 2010 goals (Source: Federal Ministry of Economics and Technology).

To become one of the most energy-efficient and greenest economies in the world, the German government will use scientifically tested monitoring every three years to determine whether actual progress is within the corridor marked out by the above development path and to what extent action needs to be taken.

The economic success is another additional benefit of the adopted measures for transforming the German energy system. Around 378,000 jobs in Germany have already been created in the renewables sector alone (Gesellschaft für Wirtschaftliche Strukturforschung (GWS) 2013).

3. COMBATING CLIMATE CHANGE– THE MEASURABLE CONTRIBUTION OF A SURVEYOR

The surveyor can play a significant role, establishing, quantifying, and managing climate change. With his specialized skills he can substantially contribute to helping mitigate and adapt climate change and to reduce climate-related risk. The following sections describe a wide range of climate change mitigation and adaptation strategies in which the surveyor is involved (cf. Interessengemeinschaft Geodäsie 2013).

3.1 Provision and Assessment of Geodata

The social coexistence in our society is today no longer conceivable without spatial information (geo-information). Decisions in management and business are estimated on base of geo-information at the most. Hence, geo-information is a very important decision basis for energy-related issues:

- Are environmental risks such as earthquakes, floods or landslides expected in the region?
- In which areas is it possible to use geothermal energy?
- Which areas are suitable for wind power priority zones?
- Which roofs are suitable for the production of solar energy?
- What property areas are affected?
- How can networks be optimally adapted for the transport of energy under various requirements?

The application of modern geographic information systems and the acquisition and evaluation of geodata therefore provide an objective basis for spatial decisions related to the energy transition. 3D city models enable a simulation of the spread of noise and emission or predictions of possible changes in the urban climates. In disaster situations, such as flooding it is possible to evaluate, on basis of 3D landscape models quickly which areas and buildings would be affected, with the result that important supporting measures can be initiated precociously (cf. Friesecke 2004, 2005).

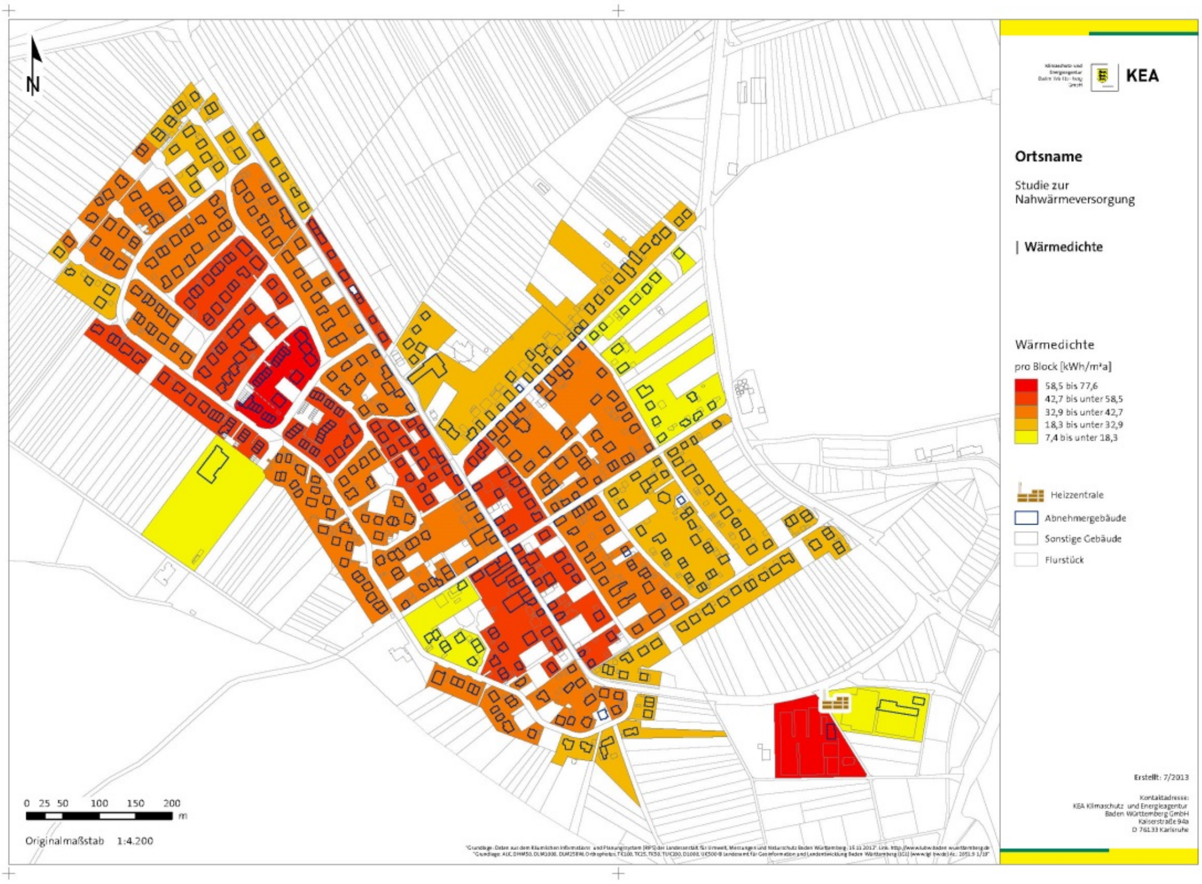

Figure 3: Local heating survey, heat density per block (Source: Klimaschutz- und Energieagentur Baden-Württemberg KEA).

3.2 Identification and Assessment of Regional Potentials for Renewable Energy

Regional potentials for the use of technologies for renewable energy can be identified and assessed with the help of geo-information. GIS is used as a “Decision Support System”. Necessary data and analysis tools base on geodetic expertise:

- Which sites are suitable for the establishment of decentralized power generation systems due to topography, establishment of roof areas or the legal planning conditions?
- Due to the average wind speed or the expected duration of sunshine, would the running of decentralized power generation be economic?
- Are there enough growing areas for renewable raw materials for the operation of biomass power plants?
- Is the necessary infrastructure available for the construction and operation of the system or the electrical power supply to the energy transport?

3.3 GIS and the Lifecycle of Plants for Decentralized Energy Systems

Decentralized energy production plants represent a huge economic value and possess a life expectancy of more than 20 years. Geo-information offers an ideal regulatory framework to arrange and manage all data and information on the life cycles of a plant. GIS-Technology is of great use to document all four stages of the life cycle of plants:

- In planning processes, GIS supports the simulation and the construction of approval documents by the provision of anticipation data.
- In the construction phase, the contractors access anticipation data to optimize and support the construction phase by GIS.
- In the O&M-Phase (Operations-and-Maintenance-Phase) GIS allows the efficient coordination of maintenance and the current monitoring of geometry of decentralized energy systems.
- GIS also supports the controlled demolition of decentralized energy systems.

Figure 4: Concept study for a biogas plant (Source: Fachagentur Nachwachsende Rohstoffe e.V. (FNR)).

3.4 Earth Observation for the Support of the Energy Transition

The world's climate is situated in a continuous change. Subjects like the melting of the polar ice caps and continental glacier regions or the steady rise in sea-level are of great interest and existentially. Even in regional or local scales occur dramatic changes. Do they represent the increasing human intervention in climate processes or are they part of a natural variability? Are we able to influence this in the context of an appropriate climate and environmental policy?

To answer these key questions, actual data such as the height of the sea-level or the length of the glacier tongue and their changes have to be gathered as accurately as possible and then classified in timelines for the detection of changes. Geodesy plays an important role in measurement, evaluation and analysis of relevant data. Thereby, geodesic sensors are deployed in space and on the earth's surface.

Surveyors work interdisciplinary and in close contact with other geoscientists as meteorologists, oceanographers, geographers and geophysicists.

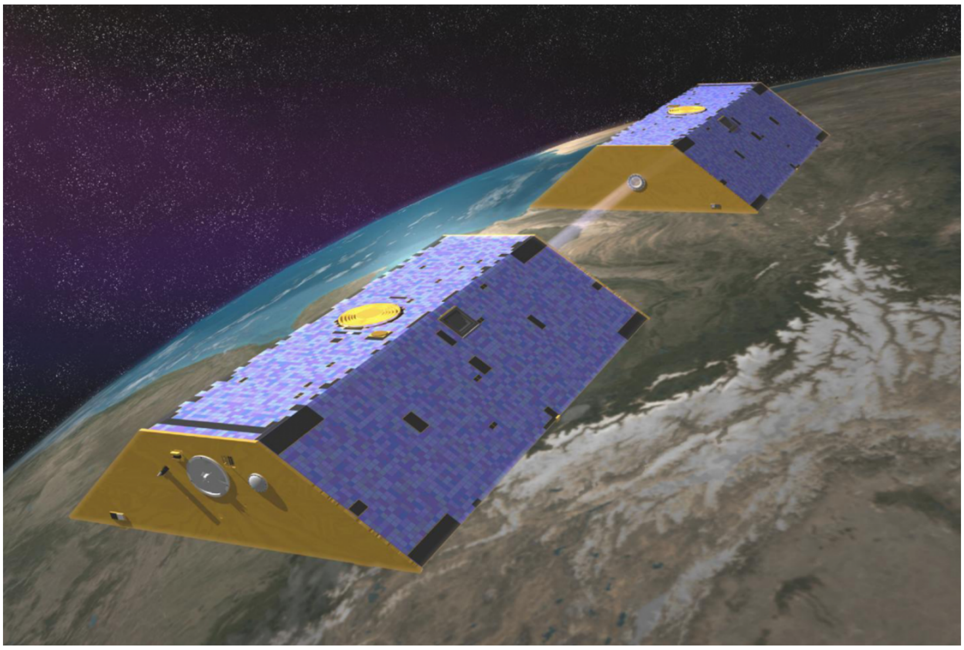

Figure 5: GRACE satellite (Source: NASA/JPL-Caltech).

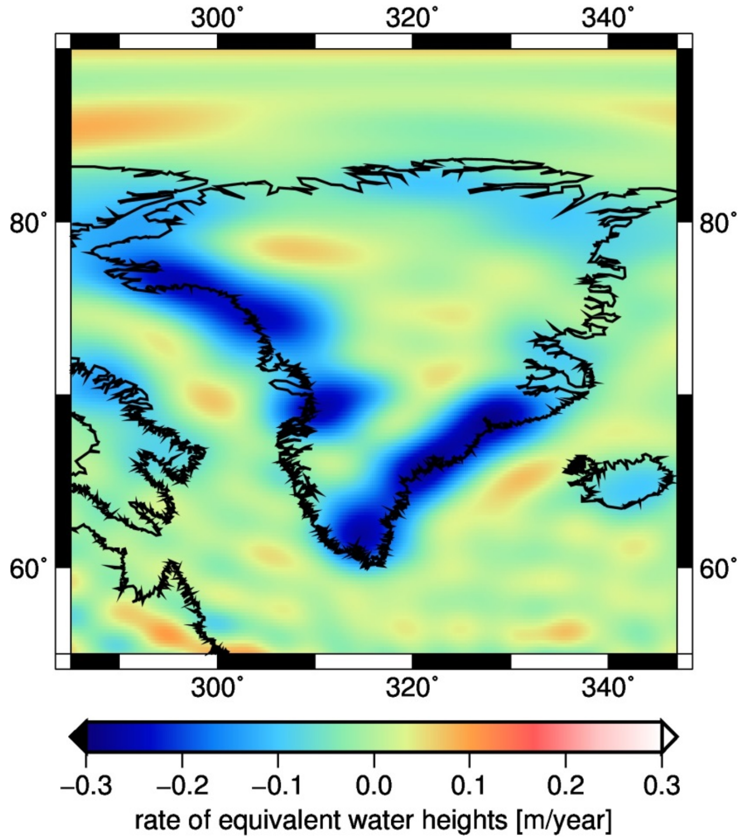

Figure 6: Ice mass change in Greenland, observed with GRACE (Source: Annette Eicker 2013).

3.5 Energy Transition not without Geodetic Measurement Methods

Using a solar cadaster, homeowners know with a few clicks, whether the roof of their house is suitable for a photovoltaic system or a solar collector for water conditioning and the heating support.

Even in this case, surveyors help: non-contact measurement methods via laser scanning enable a rapid analysis of the potential of roofs for photovoltaic. The solar potential is calculated either from genuine laser scanner data, determined through photogrammetric analysis of stereoscopic aerial photographs or derived from a 3D city model. For detection by laser scanner and aerial photographs, special aircraft are used.

Another example for geodetic measurements is deformation analyses based on tachymeter data and GPS in order to make reliable statements about any deformations or periodic properties of buildings. Geodetic applications relate mostly to engineering structures such as bridges, barrages or historical buildings that need to be monitored due to flood or earthquake hazards or natural objects such as natural slopes in mountain regions.

Terrestrial laser scanning and deformation analyses provide statements on the vibration behavior of wind turbines by land and by sea and thus deliver important perceptions especially to stability of offshore wind farms. Even to their precise cut stakeout surveyors are needed.

Laser scanner aerial survey, stereo image analysis, tachymeter data and 3D modeling support the transition to renewable energy. Geodesists provide products which Federal; state and local Governments facilitate disaster relief and energy management. They assist homeowners in planning their solar system. Hereby, surveyors make a significant contribution to a decentralized and sustainable energy.

Figure 7: Air-borne detection of roof areas (Source: Prof. Dr. Martina Klärle, http://www.klaerle.de/).

3.6 Energy-Efficient and Energy-Saving Land-Use Management

Urban and rural structures need to be adapted to climate change related to the shrinking fossil fuels and the increase of the energy costs (UN-HABITAT 2011). Although climate protection goals are mostly determined on international or national level, the regions, cities and municipalities also play an important part in the implementation of these goals (cf. Knieling/Filho 2013).

"Smart Cities" describe a process to attractive urban life, living and working environments. Spatial data help to increase the digital intelligence of the cities. In urban environments, the shift to renewable energy means, for example, the application of energy saving measures on the building level in the refurbishment and new construction of buildings, the planning of measures that help to increase the efficiency of existing power generation and distribution facilities, or the optimization of traffic flows also using renewable energy. In terms of construction, the distance between and orientation of building towards each other offers possibilities for compact settlement development, reduced land consumption and enhances the use of renewable energies or thermal energy.

Thus, climate protection and energy saving is an integrative planning approach focusing on different topics such as work, housing, social infrastructure, supply and disposal as well as traffic. The goals are a compact and energy-efficient settlement structure in hand with reduced demands for traffic and transportation as well as mixed use settlement structures. Because of this it must already be taken into account on the urban development planning level (ICLEI et al. 2009).

The rural area provides an important contribution to the energy turnaround with its necessary areas for wind energy, water power, photovoltaic and biogas. Even power grids for generating the required infrastructure and storage structure are included. Besides, land consolidation measures can result in energy savings and reduced space or land (e.g. reduced transportation costs, minimization of soil sealing, ecological compensation measures).

Figure 8: Wind park in the midst of a land consolidation measure (Source: Martin Schumann).

In the face of the strains resulting from the demographic change, the energy transition is both an opportunity and a challenge especially for structurally weak rural regions. All in all, it must be made sure that burdens and benefits of future energy generation and supply are fairly distributed between urban and rural regions.

In metropolitan and rural areas exists diverse task fields for surveyors (cf. Friesecke/Schetke/Kötter 2012):

- Which strategies and instruments of urban and rural development are available for a successful realization of the energy turnaround (including land use planning, zoning, land consolidation, village renewal)?
- How can the most suitable locations and areas for the use of renewable energy be developed and mobilized in a timely and cost-effective way?
- How can the public be successfully involved in this process?

As land managers, surveyors identify demands for action in the areas of planning and zoning for the spatial control and realization of wind power, biogas and solar collector systems and provide problem-solving approaches for suitable planning and control mechanisms. They identify potential areas, provide the necessary planning security and contribute to the acceptance of the energy transition.

The author is convinced that, facing the limited resource availability (area, financial sources, personal), the available strategies and instruments of land management need to be observed for an efficient review and development of the energy transition and offers its support.

Figure 9: Solar cadastre of the City of Emden (Source: http://gis.stadtwerke-emden.de/Solarkataster/ and http://www.simusolar.de/news.php).

3.7 My Home, my Country, my Windmill: Energy Transition and Land Valuation

Land, buildings, real estate – everything has a value. By now, immovables are dealt globally – according to importance of accurate and current valuations. Valuation assumes that geodesists provide information about the concerned object: Which owners and which areas are affected, which rights do exist? Even in valuations surveyors introduce their specialist knowledge. Self-employed engineers and engineers in committees for land values are represented in expert committees of the sections construction, estimation and strategy/planning/design. Here, exact values are calculated from various data. Important for the calculation are location and usage of a parcel as well as the existing infrastructure. With the merging of spatial data as part of the valuation of properties the role of energy is increasingly important: Has an energetic remediation been conducted (Kropp 2012)? What is the impact of wind turbines on the market value of developed parcels? How has the market value of agricultural parcels to be determined which is developed by a biogas plant? How does the planning law for wind turbines influence land values positive or negative (near to wind turbines)?

As land manager, surveyors identify a need for action in planning and zoning for the spatial control and realization of wind power, biogas, solar systems etc. and deliver appropriate solutions for planning and control instruments. They identify potential areas, provide the necessary planning security and contribute to the acceptance of the energy transition.

The author provides their support in view of the limited availability of resources (land, financial resources, personnel) and the available strategies and instruments for land management to the energy transition.

Figure 10: Construction of a solar energy plant (Source: die STEG Stadtentwicklung GmbH).

3.8 Energy Transition and Public Participation

Active participation of civil society is a fundamental principle of our democracy and a factor of success of open and transparent planning methods. This applies to preparations of a local climate protection concept and to local planning of wind power and biogas plants.

Participation processes are located in energetic urban and village renewal and in land management, whether it is the planning and use of undeveloped and developed land (real estate management, land use planning), urban or rural land reallocation or zoning by land consolidation.

In the design process of moderation processes and meditation processes both with the affected land owners and land users as well as with the interested public surveyors are able to revert to diverse positive experiences.

Especially participation processes in developing renewable energies involve competences that surveyors bring through their education and practical experience. Surveyors know much about legal links between real estate cadastre, planning and zoning and their relations to other legal norms. With this knowledge, they are able to communicate with all involved department.

The author calls for participation as interagency assignment in administration. Hence, for each individual case the suitable cooperation and participation form can be selected and developed. Initiated offers of participation have to be stabilized. Best Practice examples and successes are to make a model of a "citizen-oriented administration". Concerning this, legal modifications and adjustments have to be checked for the warranty of early participation in planning and approval procedures.

Figure 11: Public participation during the energy transformation process (Source: die STEG Stadtentwicklung GmbH).

4. CONCLUSION AND FUTURE DIRECTIONS

As described in the paper, surveyors constitute a specialist community of engineers and scientists who explore and measure our earth and near-earth space and plot what they found out. Navigation systems, topographic maps, hydrographic maps, digital elevation and depth models, city maps, 3D visualizations and evidences of the real estates in land registers arise from these data.

Surveyors acquire, evaluate and visualize geo-information as a basis for the realization of the energy transition measures in different sections such as generation, transmission, distribution, saving by solar land register, wind power priority zones or line routing.

Surveyors help to predict disasters, such as floods, earthquakes, tsunamis and thus to avoid big damages. They are involved in planning and managing Smart Grids for the expansion of renewable energies. They thus make an important contribution to climate protection.

Surveyors provide with their diverse and interdisciplinary competencies measurable solutions for a successful implementation of the energy transition:

- They involve citizens in planning processes to find solutions in close consultation with all stakeholders.
- They capture, actualize, manage, analyze and visualize spatial information by network expansion for the energy supply using a geographic information system (GIS).
- They monitor local, regional and global changes of the earth with the help of modern satellite technology, digital remote sensing sensors or automated instruments such as tachymeter.
- They develop and implement high-precision measurement techniques to support federation, state and municipalities during disasters and energy management as well as in monitoring the necessary industrial infrastructure.
- They verify properties and property rights of the citizens which are affected by planning.
- They reveal problems, options and solutions in planning and soil arrange strategies and instruments for land management in energy transition projects
- They perform valuations of properties with systems for climate protection (eg. flood protection measures) and to alternative energies such as wind, biogas or solar photovoltaic systems.

Against this background, FIG focuses on the surveyor's response to climate change, helping to build climate-proof infrastructure, increasing political relations both at national and international level, and facilitating economic, social and environmental sustainability (FIG 2006, Boateng 2010, Hannah 2013). Some conclusions and guidelines will be elaborated in form of a final report for the FIG World Congress in Kuala Lumpur in 2014.

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BIOGRAPHICAL NOTES

Dr. Frank Friesecke is director of the STEG Academy, beyond that he is project manager at the STEG Stadtentwicklung GmbH (Stuttgart, Germany, cf. www.steg.de). As partner to public and private concerns, STEG acts as consultant and service provider, as well as sponsoring and investing in all urban planning tasks. Frank's recent works and papers have explored climate change, land use planning and urban regeneration. He is chair of the FIG Working Group 8.1 'Planning Strategy for Urban Development and Regeneration', which analyses urban planning and renewal processes and their economic, ecological and social impacts.

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