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GIS based Model to optimize possible self sustaining regions in the context of a renewable energy supply

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A secure, efficient and environmentally conscious energy-supply is essential for a sustainable provision of goods and services. In the context of its international complexity the global energy industry has to cope with great challenges these days. This refers to aspects like the constantly increasing energy demand, insufficient energy conversion and transport capacities or geopolitical risks alongside others. Furthermore the possible long-time effects of CO2 emissions in relation to global warming and the challenge to meet the obligations of the Kyoto protocol have lead to an enhanced problem awareness regarding energy supply systems. Hence there are two keywords rising in decision making processes regarding our future energy system: Sustainability and Security of Supply.
Both aspects are of major interest and need to be treated carefully. Since an improvement of the current energy system towards sustainability and security of supply is also particularly determined by spatial questions, attention has to be paid to this spatial aspect when a modelling process of a possible future energy system is carried out. This namely refers to the spatial distribution of renewable energy carriers and their possible utilization in the energy system. The problem faced in this context is the in general low energy density of renewable energy carriers. Therefore it is of major interest –especially in terms of "security of supply" – to pay attention to the geographical deviation of (renewable) energy supply and energy demand.
The paper presents a modelling approach that treats this issue of the divergence of demand and supply. The model developed handles information on geographically disaggregated data of renewable energy potentials as well as geographically disaggregated

information on energy demand structures. The comparison of the identified energy potentials of the modelling process to the relative energy consumption structure results in a "balance grid" that represents the energy excess or shortage in every cell of the grid. The balance grid is the basis for modelling self-sustaining regions and allows a differentiated geographical consideration of energy production and consumption potentials.

Processing this information the model approach identifies optimized energy flows to balance all energy demand hot spots. This is applied for a special region of interest with the objective of finding one optimized setup for the whole prospected area. The final outcome of the model shows an ideally balanced energy flow structure for the whole examined region. In its simplest realization the energy flows only consider balanced flows for a full year timescale. Nevertheless these flows could also be treated on an arbitrary different timescale.

Based on these outcomes a possible sub-regionalisation in terms of energetic independency within the considered region of interest can be identified. This is reflected by clustering the region of interest into single self sustaining sub regions.

The model itself is a linear optimization model realised in the modelling language GAMS. There is an interface implemented to connect the model to common GIS software. In the current model all input and result data are administrated and visualised in ArcGIS.

The development of self-sustaining regions in terms of an energy-balance provides a valuable concept and decision support tool to promote policies and influence relevant legislative, regulatory and institutional frameworks of energy-systems.

The added value of the identification of self-sustaining regions can be found in regional decision making processes, which refers to evaluation processes and also investment decisions on the background of a self sustaining regional energy supply system.