

Mapping of heat demands and district heating potential for the federal state of Schleswig-Holstein, Germany

as part of a project to integrate underground energy storage
options into spatial planning



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2nd International Conference on Smart Energy Systems and
4th Generation District Heating, Aalborg, 27-28 September 2016

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Outline

1 Introduction

(„Energiewende“ in Germany and Schleswig-Holstein,
underground energy storage and underground spatial planning)

2 The ANGUS+ project

(overview)

3 Mapping of heat demands and district heating potential

(method, data, results)



1 Introduction

Germany:

Transition towards a fossil fuel (and nuclear power) free energy system („*Energiewende*“)
27 % of consumed electricity provided by renewables (2014)

Schleswig-Holstein:

78 % of consumed electricity provided by renewables (12 TWh in 2014)
high number of on- and offshore **wind power** plants (2,800 plants / 5,580 MW in 2016)

- fluctuating production
- federal state's power grid is currently undersized
- feed-in management by grid operators
- **2,900 GWh could not be fed into the grid in 2015**

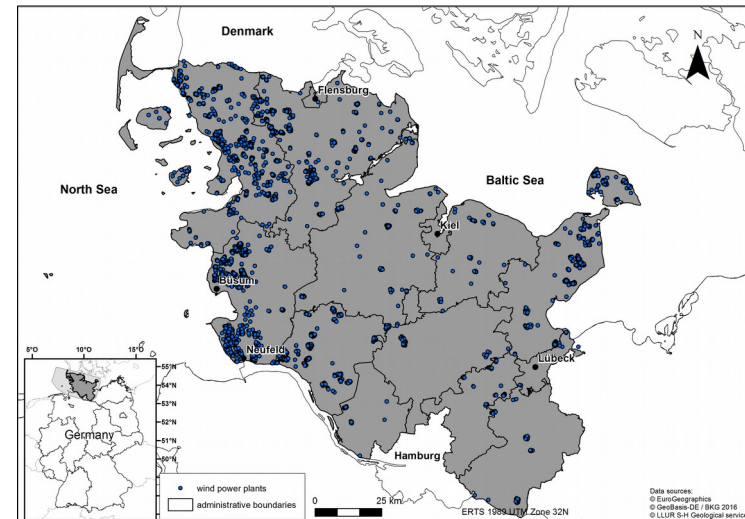
Underground energy storage

storing surplus power in shallow or deep underground
power2heat, power2gas: compressed air (CAES) or H_2 / CH_4

Subsurface spatial planning

other usages of underground space exist:

groundwater, mineral & oil extraction, geothermal energy production (fracking? CCS ?)



2 The ANGUS+ project

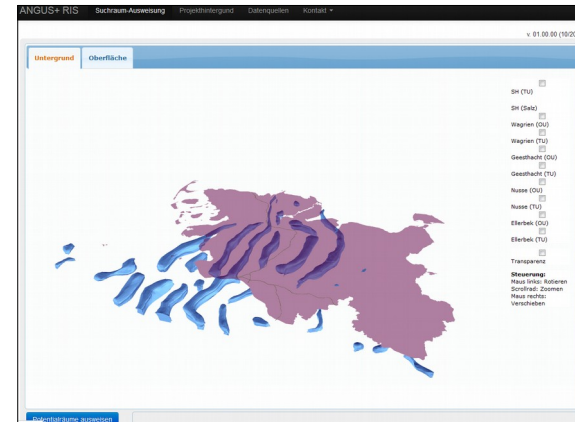
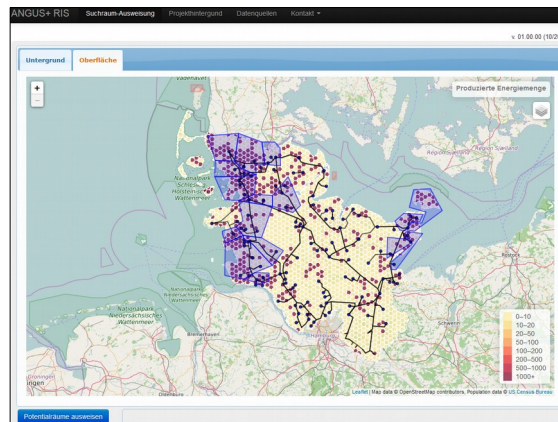
Auswirkungen der Nutzung des Geologischen Untergrundes als thermischer, elektrischer oder stofflicher Speicher im Kontext der Energiewende - Dimensionierung, Risikoanalysen und Auswirkungsprognosen als Grundlagen einer zukünftigen Raumplanung des Untergrundes

Provide basic information to integrate underground energy storage into spatial planning

- Determine geologic parameters for storage formations in S-H (laboratory experiments)
- Develop methods to model, assess and monitor spatial magnitudes of possible THMC impacts

How to identify and visualize possible suited spaces for different energy storage options?

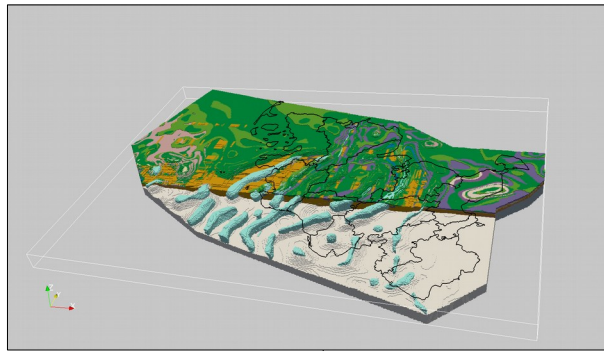
- **input data:** geological information
- **input data:** spatial data on existing and planned energy infrastructure, supply and **demand**
- **input data:** existing aboveground spatial planning and protective areas
- **3D GIS** to explore and analyze underground and land surface data sets in an integrated way



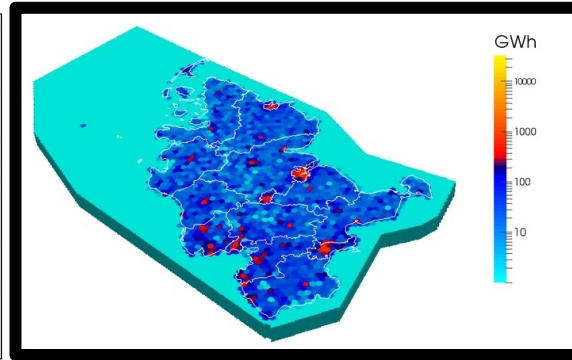
2 The ANGUS+ project

2015: no federal state-wide spatial data on heat energy demand!
(→ M.Sc. thesis Schwanebeck 2016: heat demand mapping for S-H)

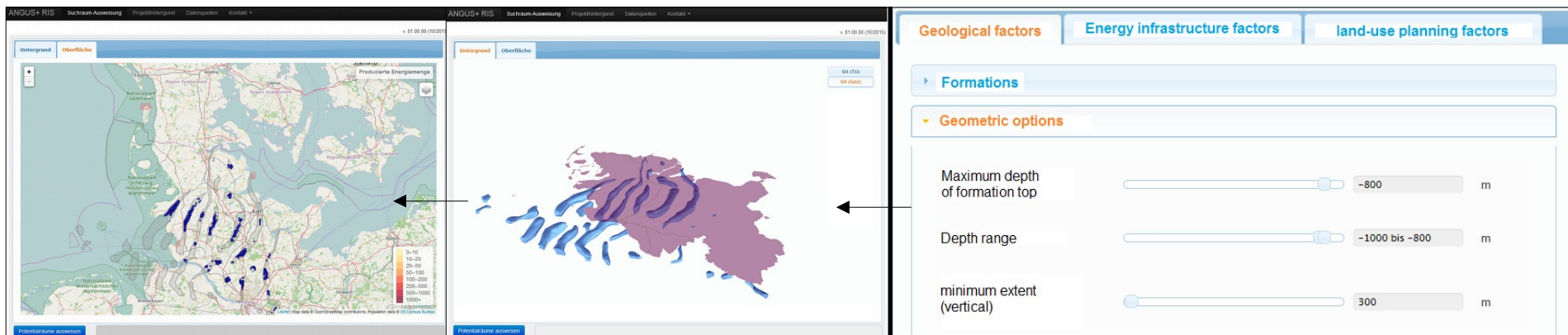
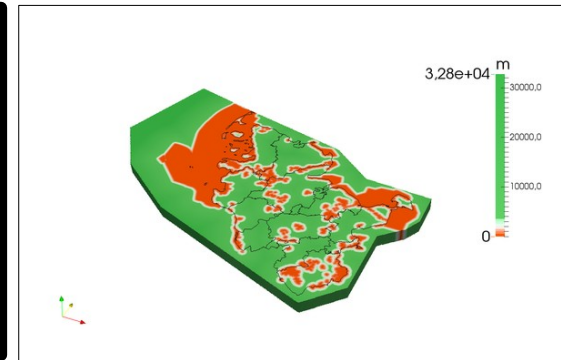
Geology



Energy infrastructure



Spatial planning



3 Mapping of heat demands

Method: Final energy consumption (FEC) for **space heating and hot water**

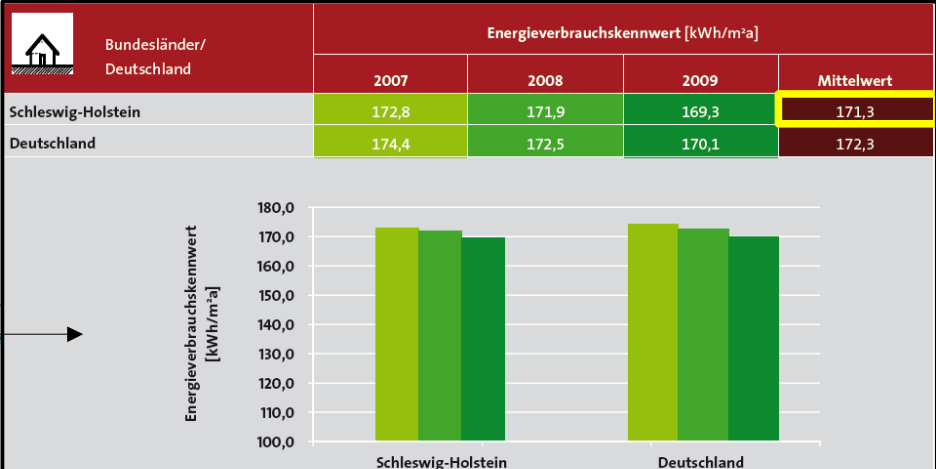
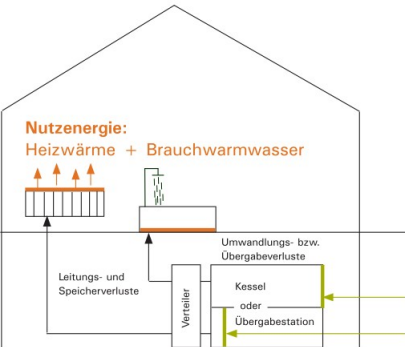
$$\text{FEC [kWh/a]} = \text{heated area [m}^2\text{]} * \text{characteristic heat demand [kWh/m}^2\text{]} \\ \text{(building type / usage?)}$$



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- residential (EFH/MFH)
- non-residential types

Ziffer nach BWZ K ⁹	Gebäudekategorie	Gebäude- größe (Netto- grundfläche) [m²]	Schreibweise für die Angabe „Gebäudenutzung“ im Energieausweis	Vergleichswerte	
				Wärme ¹⁰	Strom
				[kWh/(m² _{NGF} ·a)]	
1	2	3	4	5	6
1100	Parlamentsgebäude	beliebig	Parlament	70	40
1200	Gerichtsgebäude	≤ 3.500	Gericht bis 3500 m²	90	20
		> 3.500	Gericht über 3500 m²	70	25
1300	Verwaltungsgebäude, normale technische Ausstat- tung (ohne BWZK Nr. 1311, 1320, 1340 und 1350)	≤ 3.500	Verwaltung bis 3500 m², norm. Ausst.	80	20
		> 3.500	Verwaltung üb. 3500 m², norm. Ausst.	85	30
1311	Ministerien	beliebig	Ministerium	70	30
1320	Verwaltungsgebäude mit höherer techn. Ausstattung ¹¹	beliebig	Verwaltung, höhere techn. Ausst.	85	40
1340	Polizeidienstgebäude	beliebig	Polizeidienst	90	30
1350	Rechenzentren	beliebig	Rechenzentrum	90	155



sources: ArGe 2012
BMWi 2015
StMUG 2012

3 Mapping of heat demands

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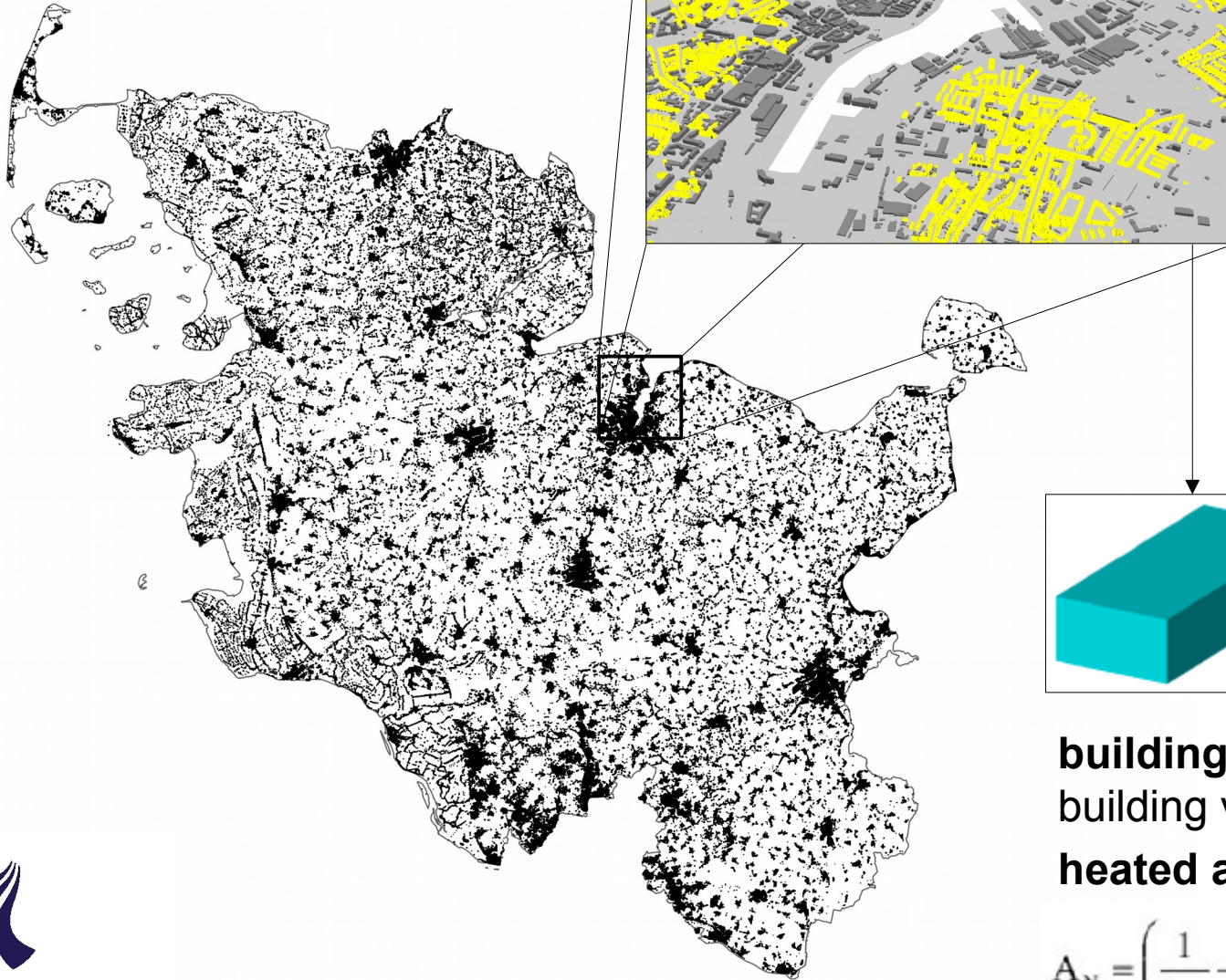
$$\text{FEC [kWh/a]} = \text{heated area [m}^2\text{]} * \frac{\text{characteristic heat demand [kWh/m}^2\text{]}}{\text{(building type / usage?)}}$$



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3 Mapping of heat demands

Data: 3D building model (LoD1)



building type (n of G)

building volume (V_e)

heated area (A_N):

$$A_N = \left(\frac{1}{h_G} - 0,04 \text{ m}^{-1} \right) \cdot V_e$$

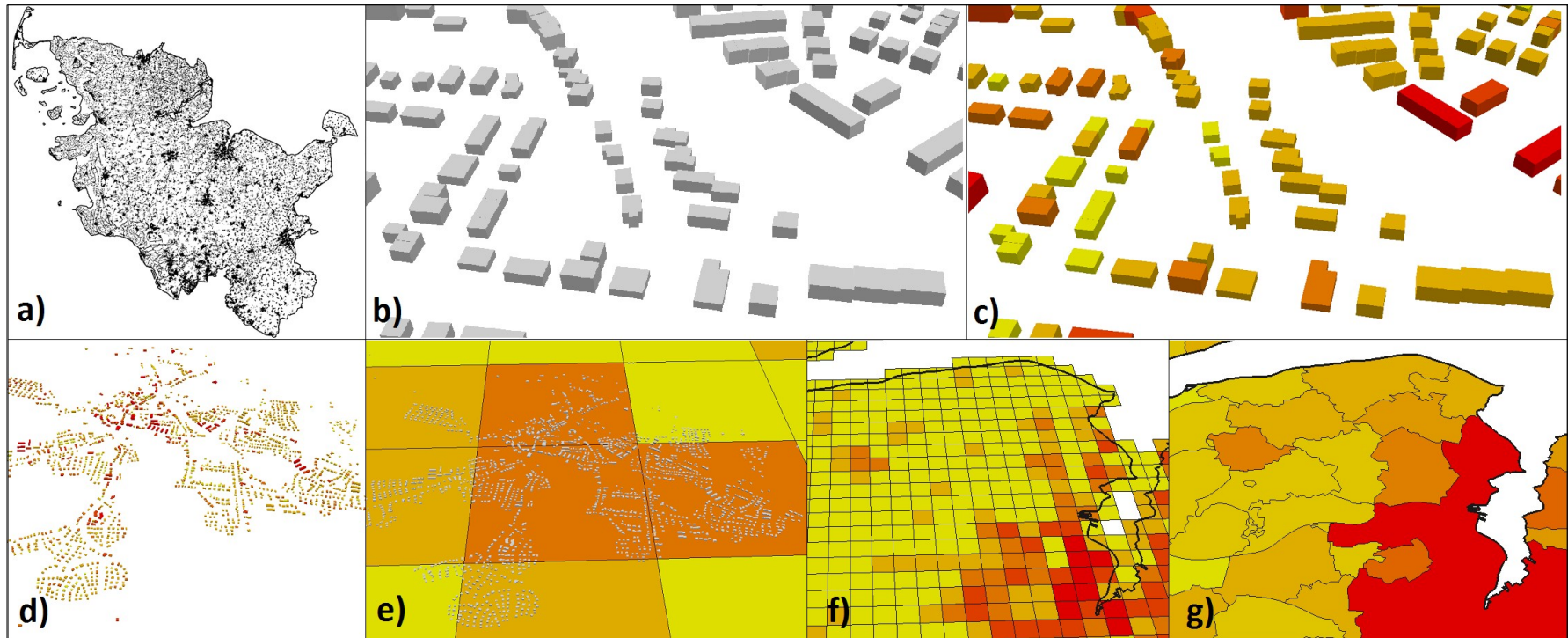


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3 Mapping of heat demands

Method overview

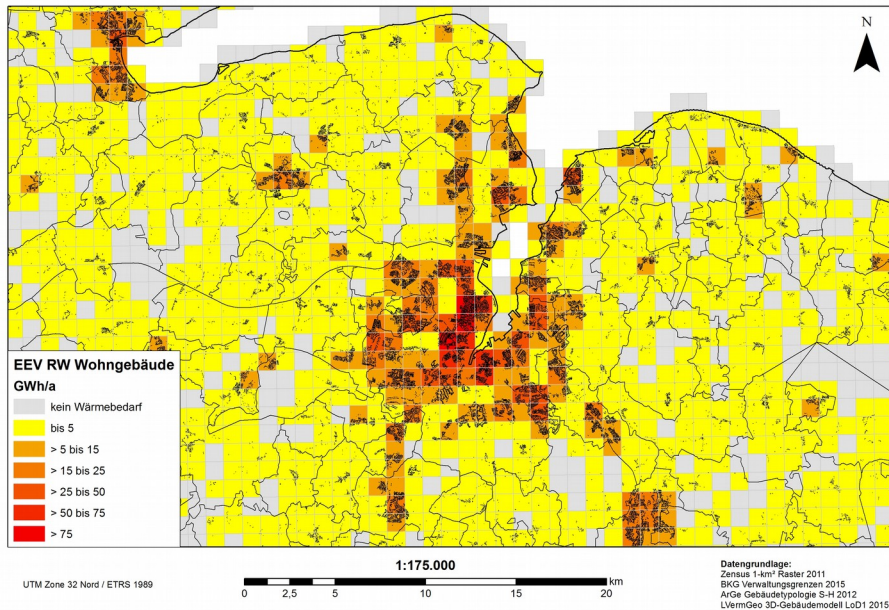


3 Mapping of heat demands

Results: heat demand for space heating and hot water (1 km² grid cells)

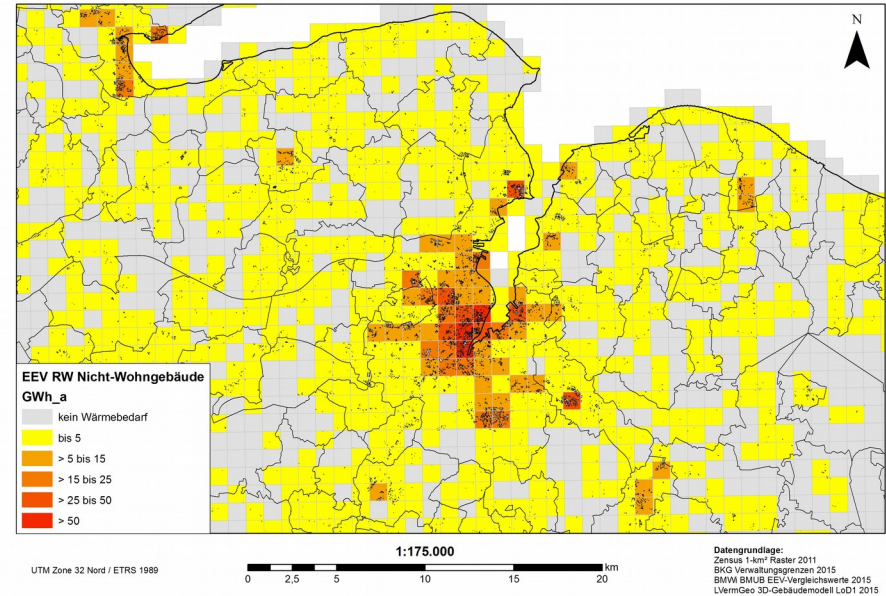
residential buildings

Wärmebedarf von Wohngebäuden



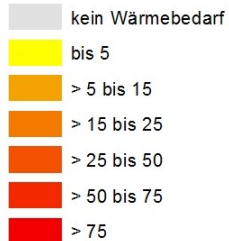
non-residential

Wärmebedarf von Nicht-Wohngebäuden



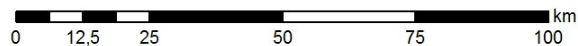
Annual heat demand of residential + non-residential buildings

GWh_a



UTM Zone 32 Nord / ETRS 1989

1:1.000.000

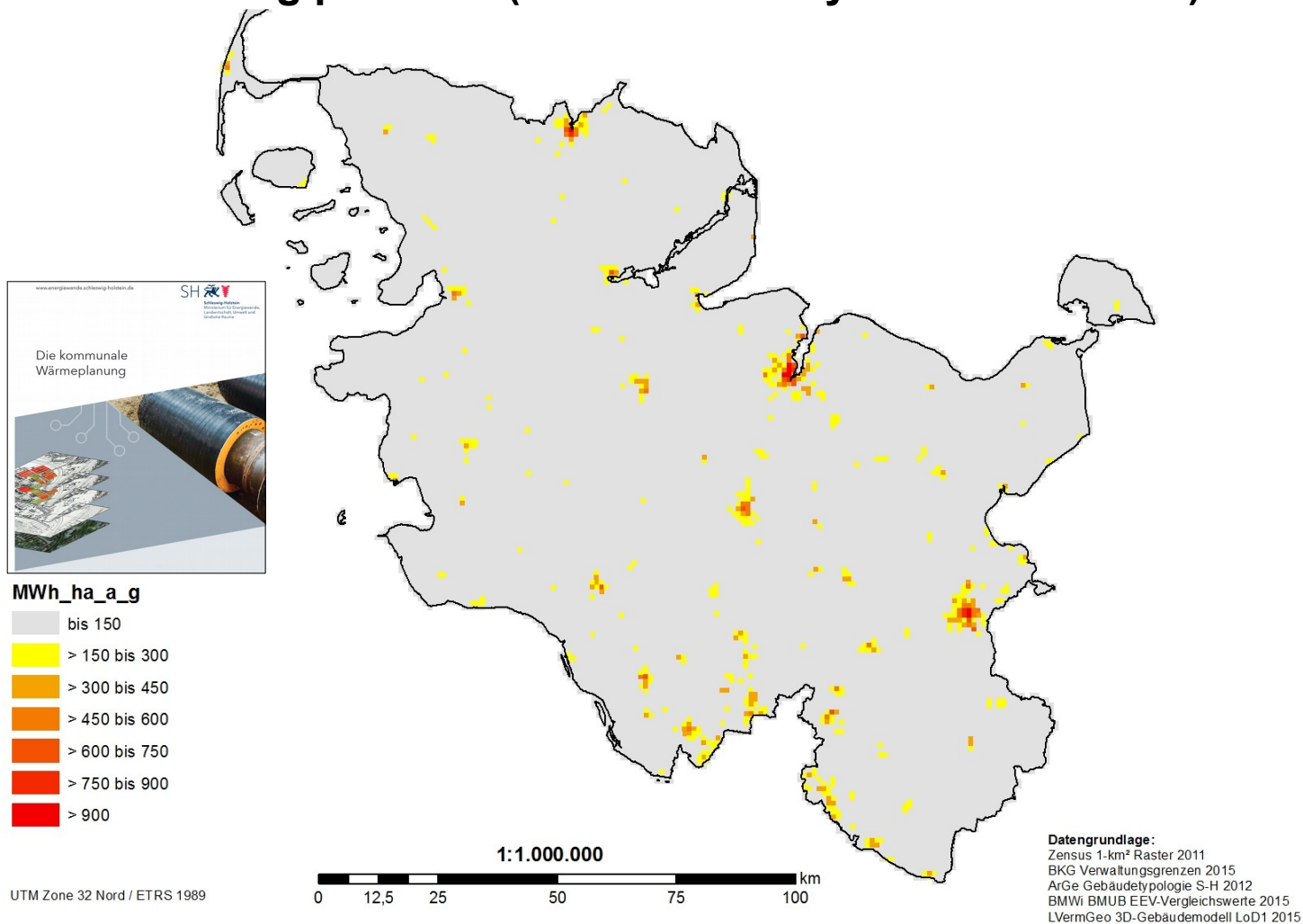


Datengrundlage:

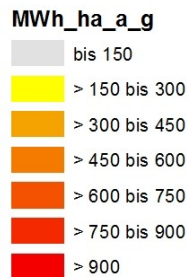
Zensus 1-km² Raster 2011
BKG Verwaltungsgrenzen 2015
ArGe Gebäudetypologie S-H 2012
BMWi BMUB EEV-Vergleichswerte 2015
LVermGeo 3D-Gebäudemodell LoD1 2015



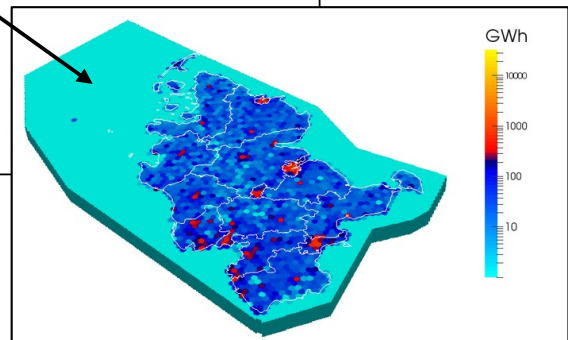
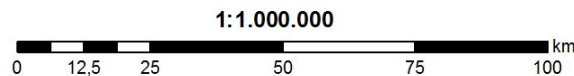
District heating potential (demand density > 150 MWh/ha*a)



District heating potential (demand density > 150 MWh/ha*a)



UTM Zone 32 Nord / ETRS 1989

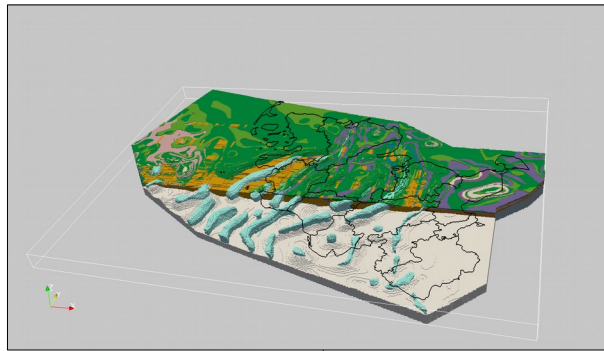


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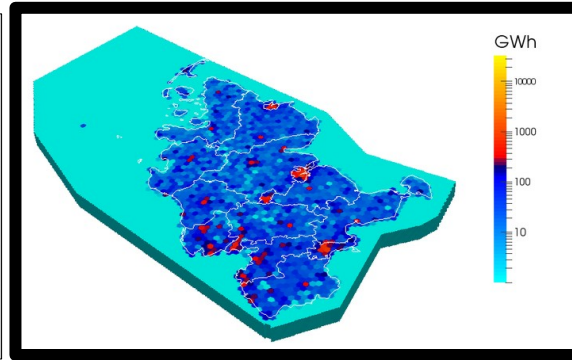
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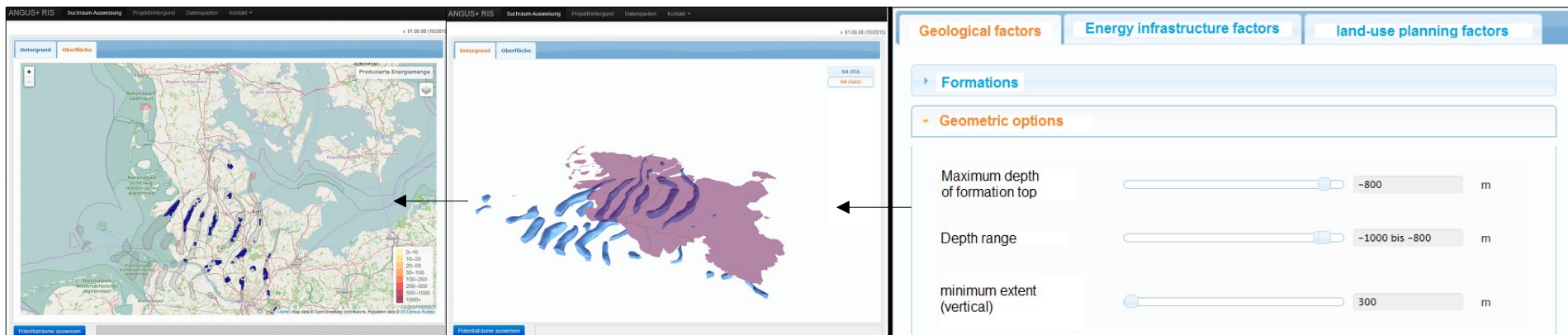
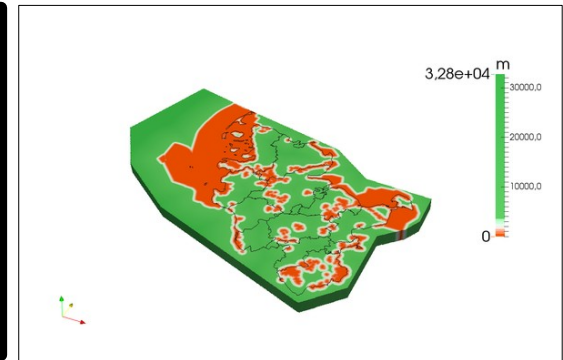
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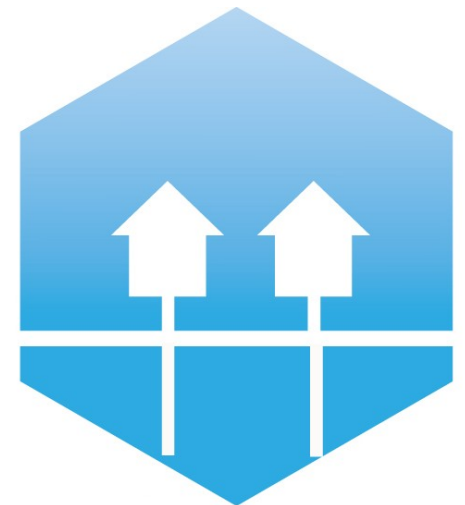
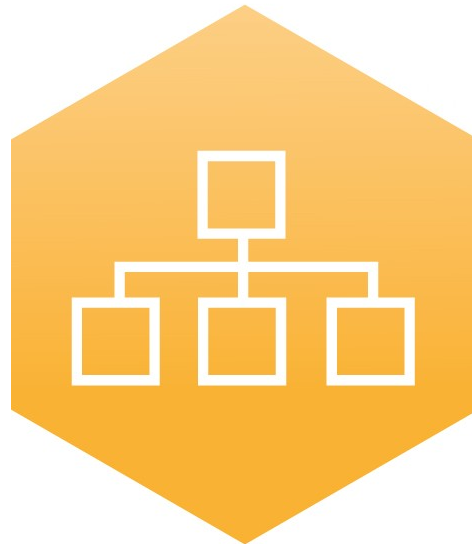
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4DH

4th Generation District Heating
Technologies and Systems