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GIS-based analysis of renewable energy potentials in urban space

UP-RES
Urban Planners with Renewable Energy Skills

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Content

Introduction

About UP-RES

1. Introduction

Energy planning is a cross section task and concerns a lot of different professional responsibilities such as:
- Energy sector
- Environment issues
- Architecture
- **Urban planners**

Energy planning contents a lot of functions for example:
- Planning
- Coordination
- Analyzing
- Process management
- Consulting
- Law issues
- Engineering

UP-RES
Urban Planners with Renewable Energy Skills

1. Introduction

UP-RES inceares awareness of integrativ energy planning

UP-RES project teaches urban planner to:

- Pay attention on energy consumption and emissions
- Make sure

Need of GIS-based energy planning

UP-RES
Urban Planners with Renewable Energy Skills

GIS-based energy planning in urban space

2. GIS-based energy planning in urban space

2.1 About GIS

What is GIS?
- GIS (geographic information system) is a computer-based system with the necessary hardware, software and data.

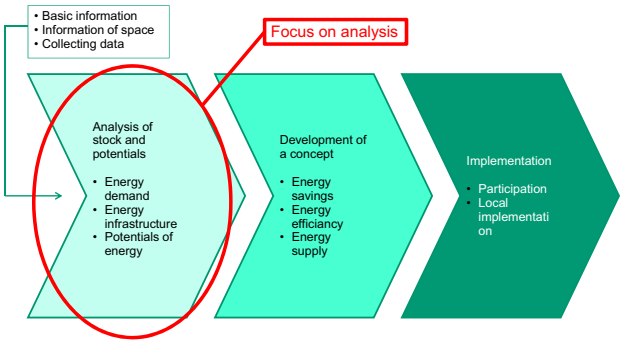
What does GIS?
- GIS gather, transform, analyze and produce information which is related to space (Earth).

Why GIS in energy planning?
- Specific interrogiation of energy planning can be answered by connecting geographical, public or private statistics in dependence of space and time.
- For example, GIS can find structures, capacities and locations of renewable energy ussues.

How to use GIS (in general)?
- Step 1: Gathering and archivying data
- Step 2: Transforming and illustrate data
- Step 3: Spatial analysis and processing information

2. GIS-based energy planning in urban space

2.2 Steps of energy planning



2. GIS-based energy planning in urban space

2.2 Steps of energy planning – Basic informations

For GIS-based applications several basic information is needed such as

- Materials for visualisation: **aerial image**

Content of aerial image:
- Waters and natural structures
- Land use
- Housing, Infrastrukture and agriculture

2. GIS-based energy planning in urban space

2.2 Steps of energy planning – Information of space

For GIS-based applications several basic information is needed such as

- Materials for visualisation: **plan of typs of buildings**

Content of plans:
- Land use for housing
- Structure of buildings
- Density and height
- Special and other using

2. GIS-based energy planning in urban space

2.2 Steps of energy planning – Collecting data

There are several possibilities to collect data, either public or private source:

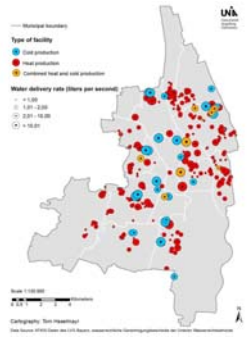
- Local department of housing, citicens, trade and industry
- Building authority
- General supplier (energy, water)
- Promotion of economy
- Private housebuilding (companies, architects)

Total energy consumption per building:

ID	Street	Number	Consuption (kWh/a)
1	Mainstreet	5	45.000
2	Mainstreet	7	50.000
3	Mainstreet	9	30.000
4	Longstreet	2	70.000
5	Longstreet	4	55.000
6	Longstreet	6	45.000

Potentials of renewable energies in the city of Augsburg

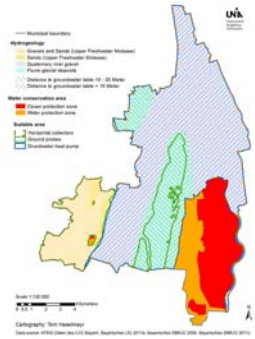
Exemple 1: Near-surface geothermal energy



Current situation: Groundwater heat pumps
- 358 facilities of heat production
- 26 facilities of cold production
- 9 facilities of combined heat and cold production

Water delivery rate as an indication for the capacity of the heat pumps

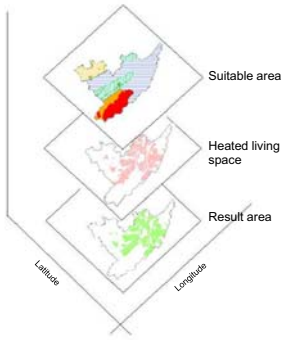
Delivery rate of about a liter per second necessary for an evaporation capacity of 14 kW (Heat for a four-person-household)



1. Step

Identify suitable areas by defining exclusion criteria

Influence parameters:
- water conservation areas
- geohydrological conditions
- Legal restrictions



2. Step

Spatial intersection analysis

Find out the total heated living space located in the suitable area

→ Result
2178 acres (85 %) are located in the suitable area

3. Step

Calculate heat demand
based on average heat demand of residential buildings in Augsburg
(90 W per square meter)

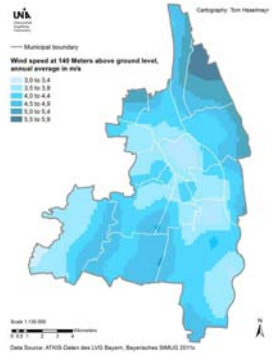
4. Step

Determine heat pump coverage
→ 36 % is possible according to the German Heat Pump Association

→Result 430.000 MWh per anno can potentially be generated

Potentials of renewable energies in the city of Augsburg

Exemple 2: Planning of wind energy



1. Analysis of wind conditions

Quantify avarage wind speed

Influence parameters:
- Density of buildings
- Thermal activities (turbulence)
- Mirco climate advanteges and disadvanteges (locally)

3. Potentials of renewable energies in the city of Augsburg

3.2 Example: Planning of wind energy in Augsburg/Germany

2. Definition of excluded areas:

- Natural reserve
- (Natural) conservation area
- Residential area with a buffer of 800 m
- Industrial area with a buffer of 500 m

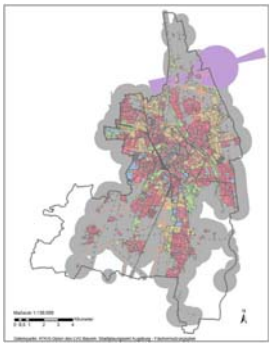
➔ Prohibition of wind energy

Different land use is competing to each other:
- Area designated to protection of birds
- Wind power plants

Regional plans distribute permission/possibility to wind energy
➔ Restricted or preferred area

3. Potentials of renewable energies in the city of Augsburg

3.2 Example: Planning of wind energy in Augsburg/Germany



3. Mapping the available space

Summery of land use:

Map shows areas of non-permission to wind energy facilities **(method of elimination)**

- No housing areas
- No industrial areas
- No infrastructur (traffic)
- No natural reserve
- No transition zone

3. Potentials of renewable energies in the city of Augsburg

3.2 Example: Planning of wind energy in Augsburg/Germany

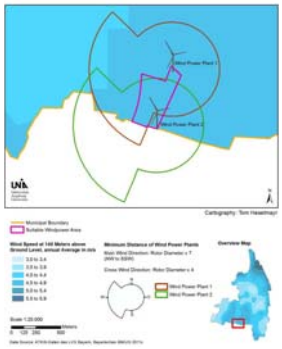
4. Calculation of annual energy yield:

- Avarage wind speed
- Usable space
- Efficiency of wind power plants

➔ Potential wind energy

3. Potentials of renewable energies in the city of Augsburg

3.2 Example: Planning of wind energy in Augsburg/Germany



Energy planning:
- Compare usable space and available technology
- Pay attention to legal issues

➔ Two wind turbines are realizable

5. Next steps:

- Implementation at municipal level
- Authorization procedure; environmental impact assessment
- Implementation in local (urban) plans
- Set permission for wind energy facilities in binding law

4. Total renewable energy potential in the city of Augsburg

Development potential

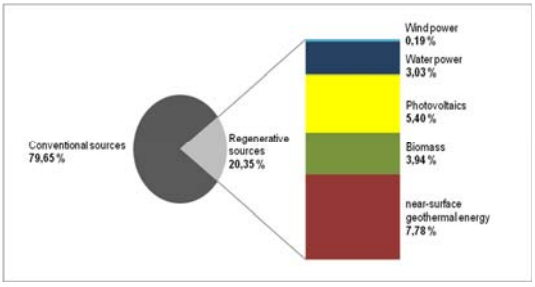
Renewable energy resource	Electricity MWh	Heat MWh
Wind power	10.718	-
Water power	89.164	-
Biomass	89.399	127.714
Photovoltaics	288.383	-
Near-surface geothermal energy	-	428.342
Deep geothermal energy	$2{,}80\times10^{8}$	$4{,}17\times10^{8}$
Sum	**477.664**	**556.056**

- Deep geothermal energy not included in the sum
- Wind power plays a minor role
- Only critical sites remaining for water power
- Huge biomass potential
- Huge potential for photovoltaics (rooftop and ground-mounted systems)

4. Total renewable energy potential in the city of Augsburg

Share of renewable energies in grid-based heat and electricity supply

Development potential **+** realized renewable energy share



New technologies of regenerative urban energy production

4. New technologies of regenerative urban energy production

4.1 Example: Urban wind turbines

Small-scale turbines especially designed for urban conditions make it possible to use the city's wind potential on exposed locations

Systems with vertical rotation axes are preferred
- Little noise emissions and shadow flicker
- No wind-tracking necessary
- Suitable for weak wind conditions due to a low start-up speed


http://www.quietrevolution.com/gallery.htm

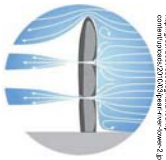

http://www.huebner-giessen.com/uploads/pics/WindStreamer1.jpg

4. New technologies of regenerative urban energy production

4.1 Example: Urban wind turbines

Pearl River Tower, Guangzhou, China

- Construction work finished in 2011
- New approach to urban wind energy
- Building-integrated turbines
- Four funnel-shaped openings to catch the wind
  → Increasing wind speed due to a reducing diameter
- Approx. one million kWh can be produced per anno
- Homogeneous integration in the cityscape
- Increases public acceptance


http://greenbusinessblog.natur.de/wp-content/uploads/2010/03/pearl-river-tower-2.jpg


http://i140.photobucket.com/albums/r5/z0rgg/PearlRiverTower5_t1kHw1YNNVCM.jpg


http://www.chinaurbandevelopment.com/wp-content/uploads/2011/11/Guangzhou_CBD-7.jpg

4. New technologies of regenerative urban energy production

4.2 Example: Drain-water heat recovery

Method suits perfectly for the conditions in urban space
- Waste waters from households and industrial enterprises are available in huge amounts
- Heat consumers are in the immediate environment

3 subtypes of drain-water heat recovery
- Inside the building (high temperature level, low water discharge)
- Inside the canalization (medium temperature level and water discharge)
- At the outlet of a sewage plant (low temperature level, high water discharge)

→Use in canalization has been proven as the most practicable method

Minimal requirements
- water discharge of 15 l/sec
- Heat consumer with a demand of 150 kW
- Distance less than 300 m between source and consumer

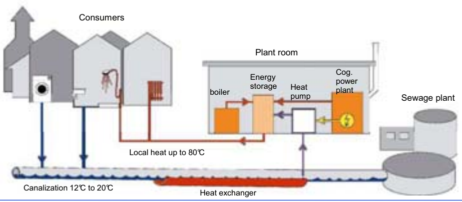
4. New technologies of regenerative urban energy production

4.2 Example: Drain-water heat recovery

Straubing, Germany

Drain-water heat recovery system can supply heat for more than 100 apartments
- Works with a bypass cycle to separate drain water from process water
- Electrical compression heat pump increases temperature
- Seasonal performance factor of 4 can be realized
- Energy for the heat pump comes from a local cogeneration power plant

→ Whole system is powered by renewable sources

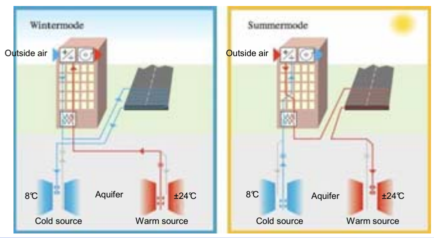


http://www.wz-straubing.de/RET/download/090209_pop_abwasserwaermenutzung_kanalnetz.pdf

4. New technologies of regenerative urban energy production

4.3 Example: Asphalt solar collectors

- Technology based on a everyday phenomenon
- Dark and rough structure of asphalt leads to a high absorption rate of sunlight
- Cities offer good conditions for the technology due to a multitude of tarred streets and places
- Works with two separated natural reservoirs
- Used for Cooling and Heating
- 270 kWh can be gained out of one square meter



http://www.ihsenergy.co.uk/format/images/pdf/ihs_brochues/Road_Energy_System_Brochure.pdf

4. New technologies of regenerative urban energy production

4.3 Example: Asphalt solar collectors

- Technology is brought one step further at the Worcester Polytechnic Institute, USA
- Electricity can be generated using the Seebeck-effect
  → Formation of voltage between two contacts of conductive materials differing in temperature
- Energy production after sunset is possible
  → Asphalt stores heat very well
- Positive side effect: Asphalt temperature is sinking
  →Urban heat island effect is reduced

http://www.icax.co.uk/images/laying_pipe_arrays.jpg

Conclusion

5. Conclusion

- With the help of GIS → analysis of renewable energy potentials on spacial approach
- Advantageous because of competition of space and using
- Energy planning: Combination of different steps, tasks, and participants
- Energy planning: Realization of urban energy concepts need an GIS-based analysis