

# Spatial Agent-based Simulation

Thermal Energy Transition Pathways in Urban Environments  
Smart Energy Systems 2019, Copenhagen

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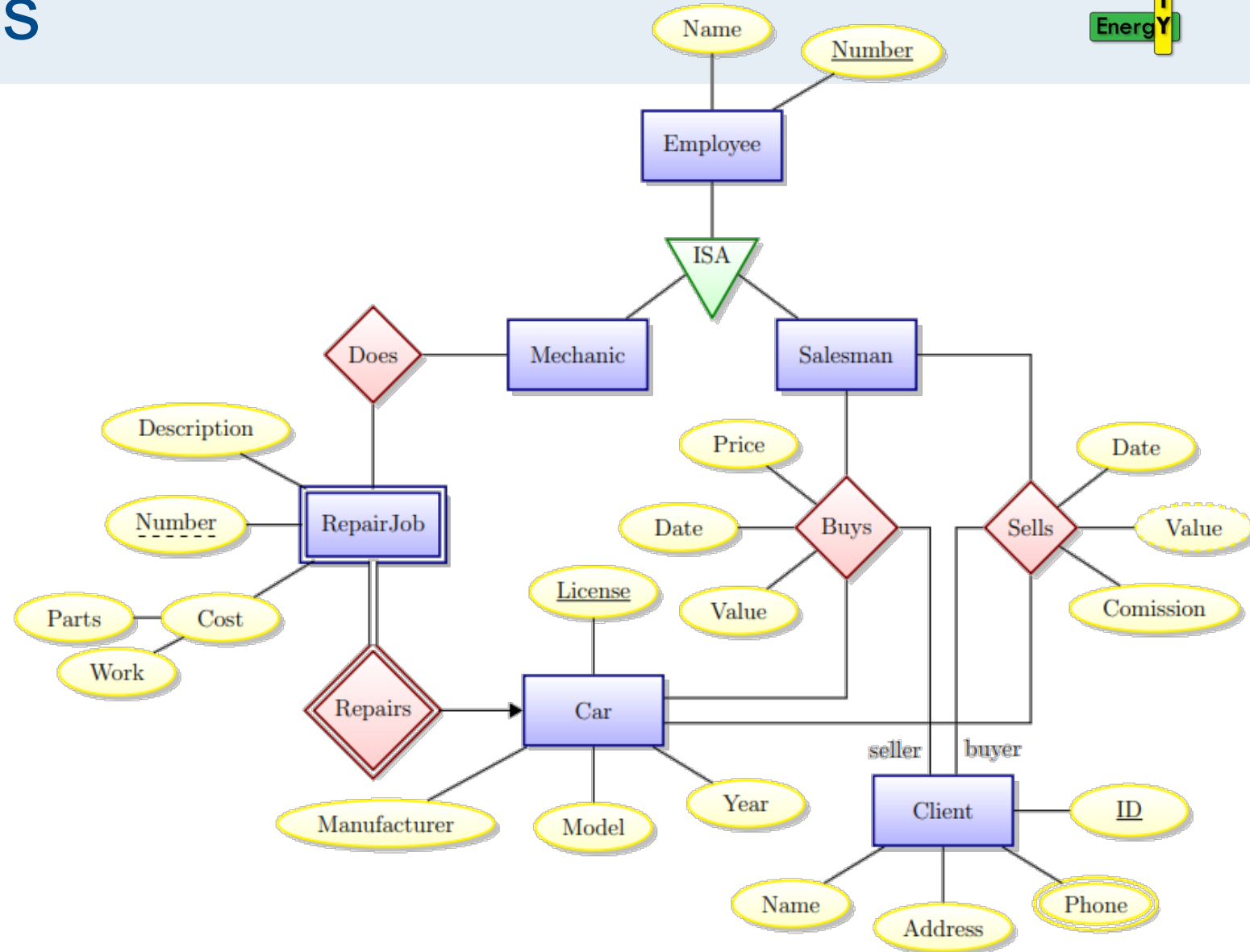
# Motivation

# Relationships..

..matter



- Influence
- Connect single parts
- In
  - Social systems
  - Technical systems
  - Mixed systems





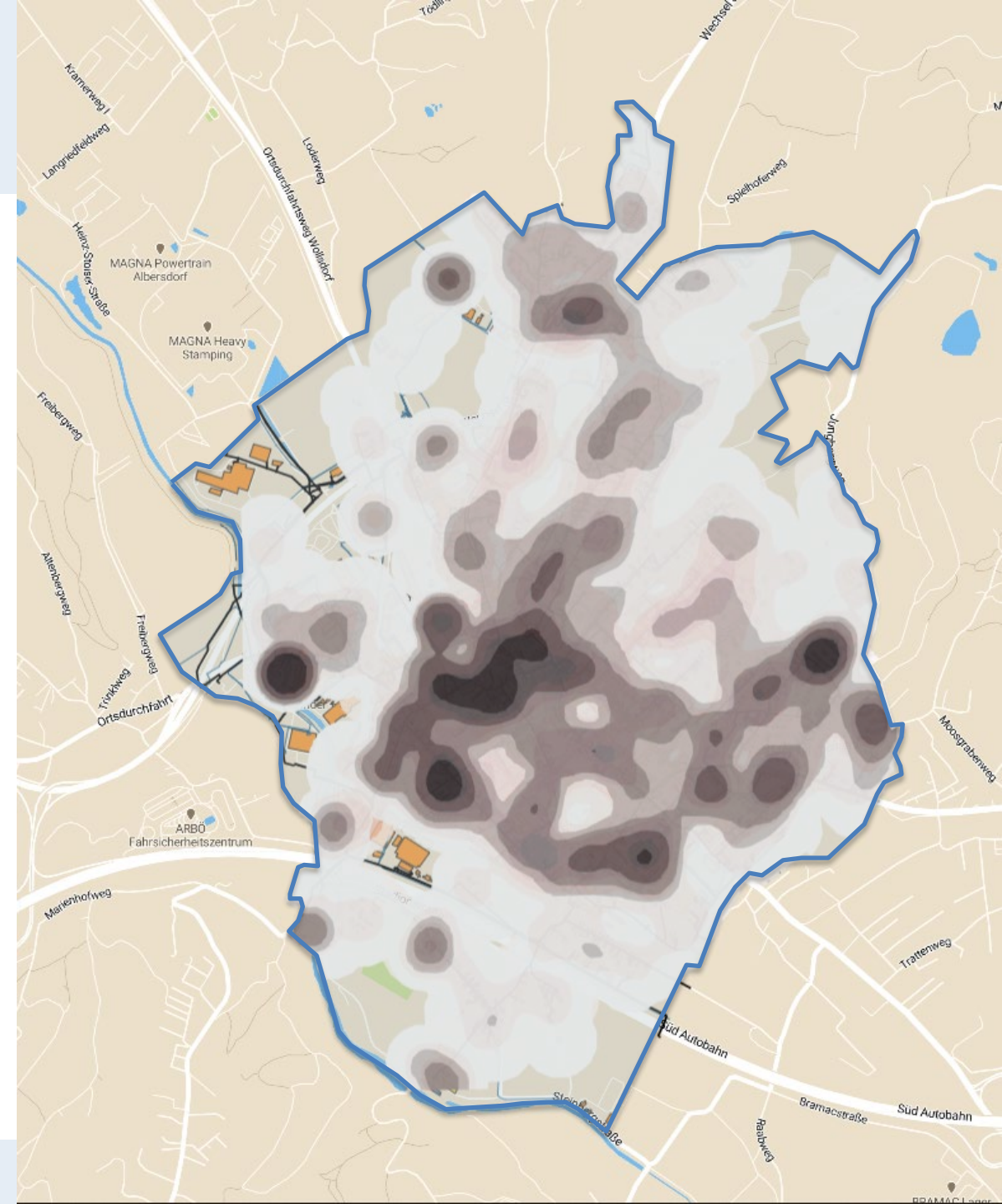
# In our case

- Small city
- Buildings
- Energy infrastructure
- Citizens



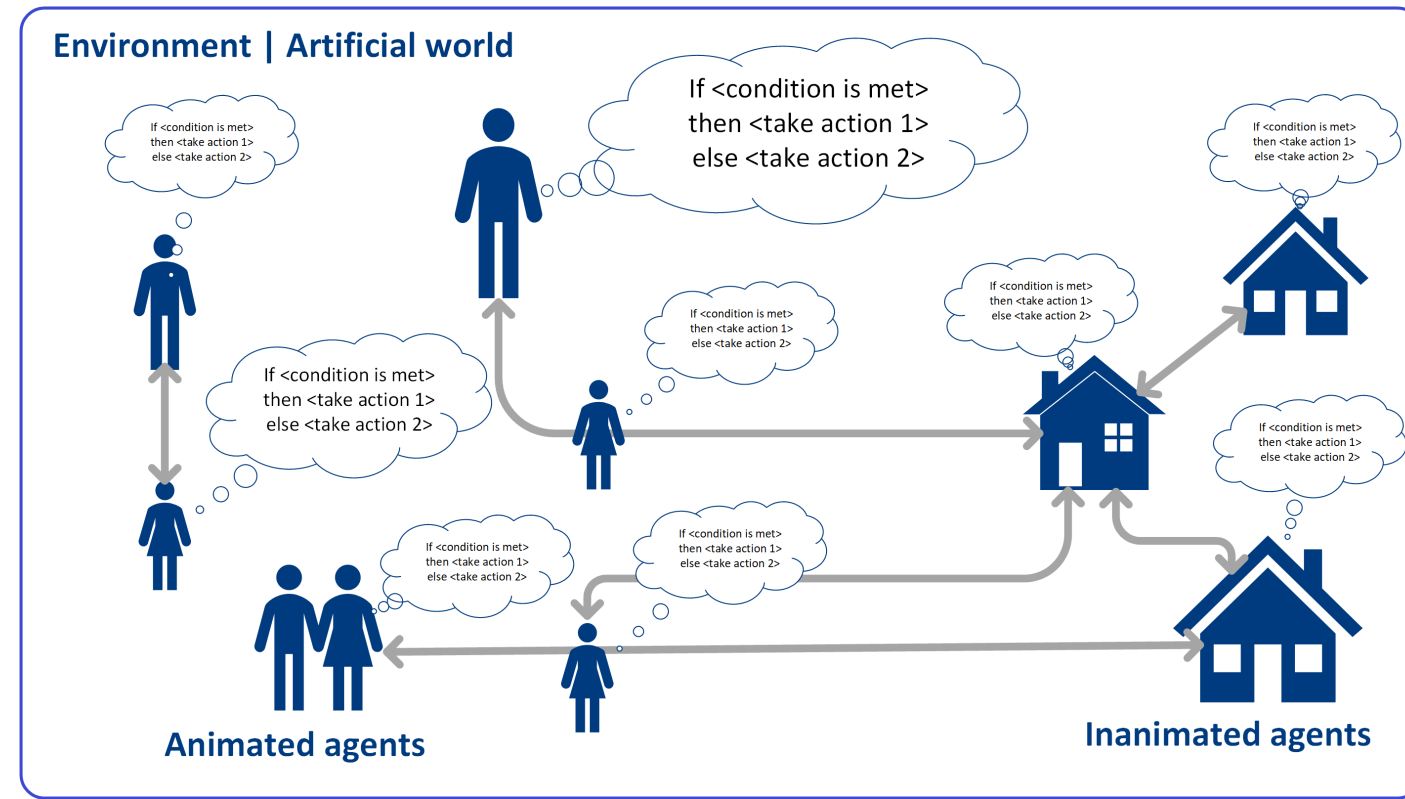
# We were curious about

- How this connections influence
  - The future development of
    - Heat energy demand
    - CO<sub>2</sub> emissions
  - In transition scenarios
  - Depending on different factors
    - Technical
    - Socio-economic
  - Residential buildings
    - Renovation quality and rates
    - Change of thermal energy system



# How did we do it?

- Agent based modelling – ABM
  - Methodology to model interactions
  - Widely used in social sciences, economics, etc.
  - Agents represent single entities
    - e.g. Citizens, Buildings, Networks, etc.
  - Agents possess characteristics
  - Variability
    - Random functions
- Tool
  - Gama



*Adapted from Heppenstall & Crooks, A. „Agent-based Modeling in Geographical Systems“. In: Access-Science (2016)*

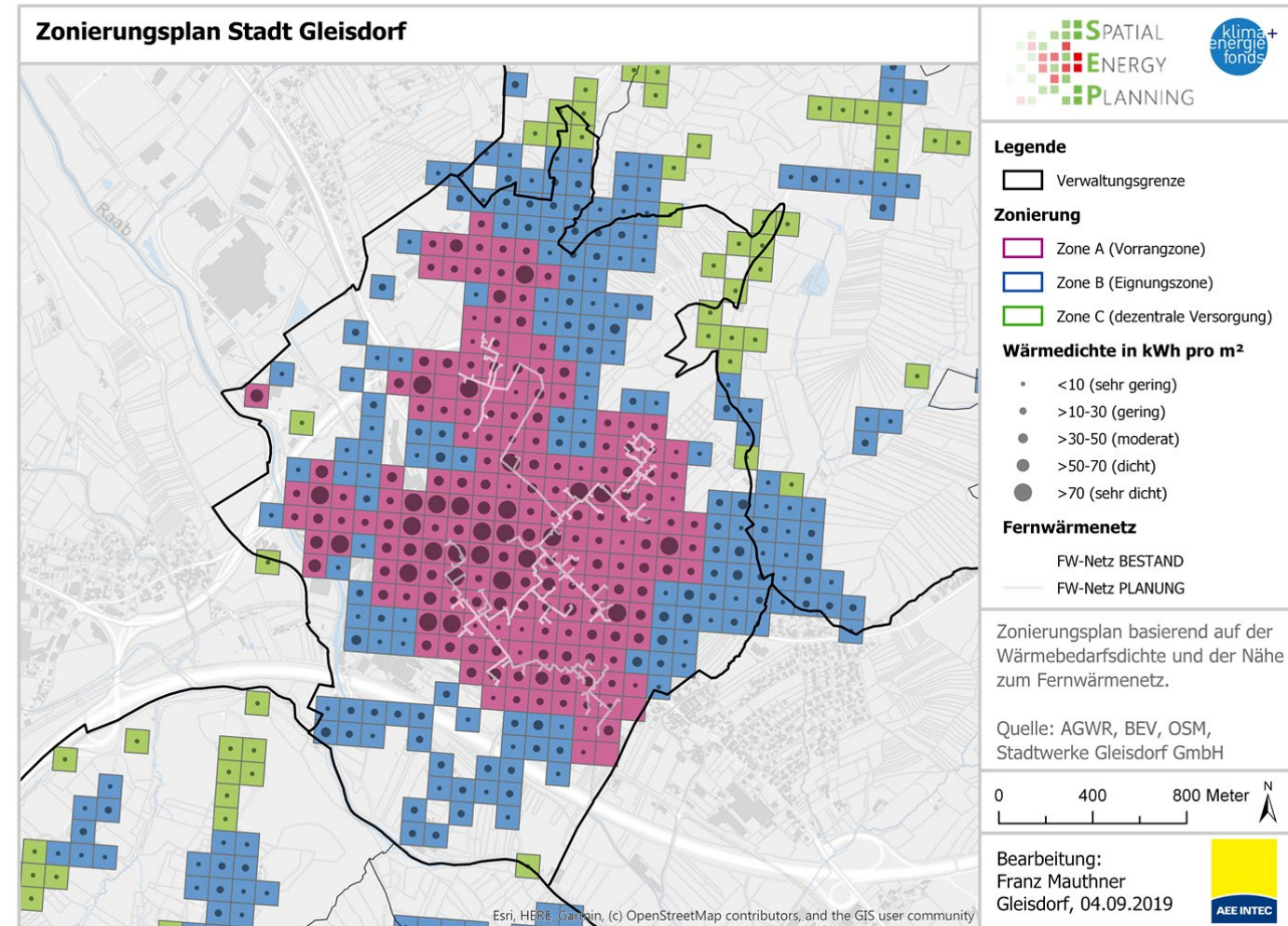


## ■ GIS

- Spatial data base
  - Heat energy demand, CO<sub>2</sub> emissions, renovation status, heating system, etc.
  - for the City of Gleisdorf

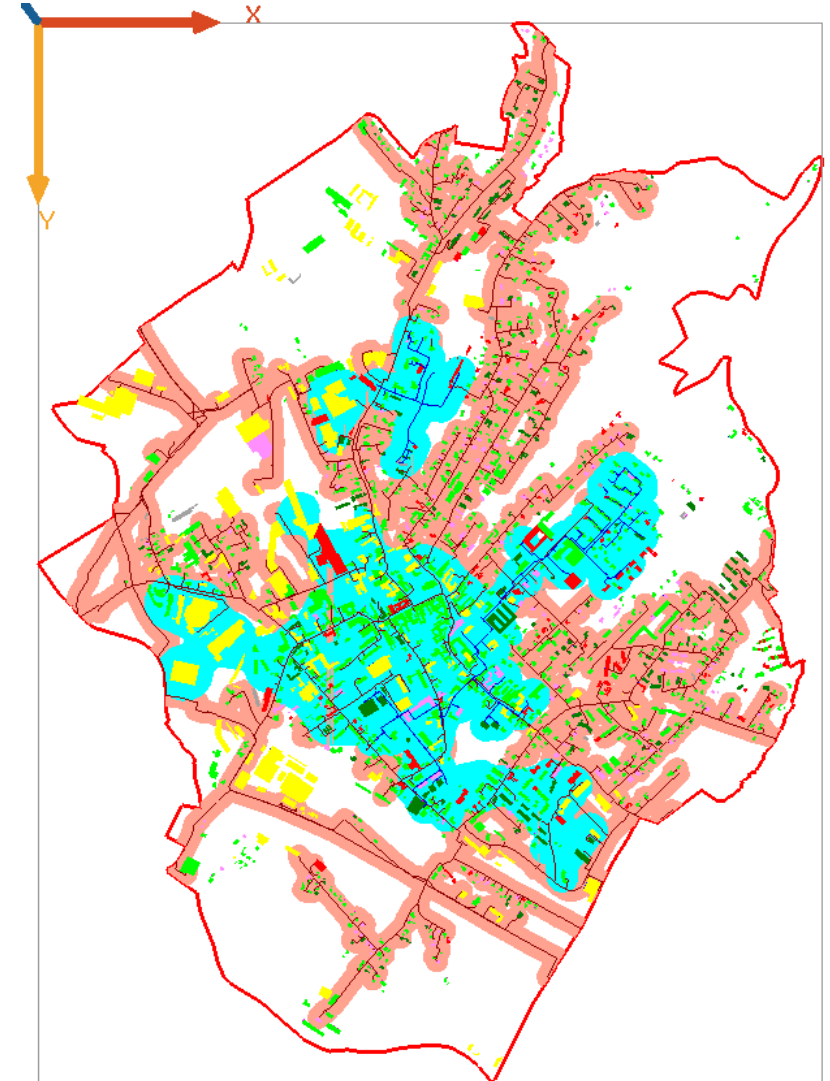
## ■ Spatial energy planning

- Link spatial energy analysis with socio-economic effects
- Simulate complex dynamics
- Implement decision making processes



# ..using agents like..

- Building agents
  - Building
    - age, renovation status & quality, heating system
  - Owner
    - age, education level, status of employment
- Network agents
  - District heating, natural gas
- Potential zone agents
  - Heat pump, biomass, solar, etc.
- Environment agent
  - City of Gleisdorf

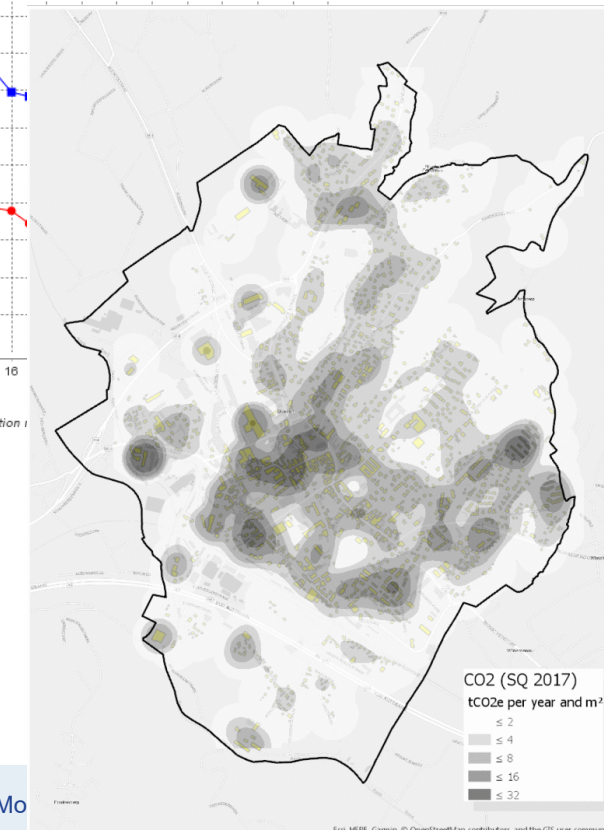
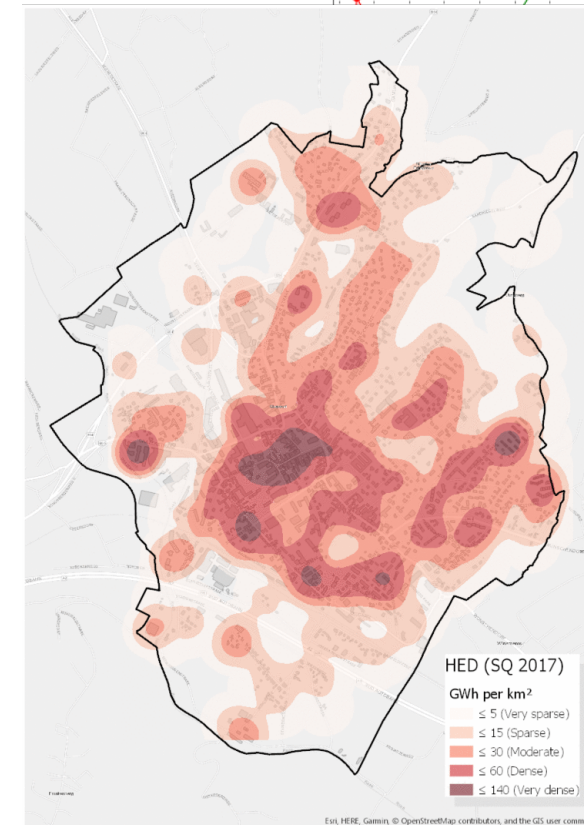
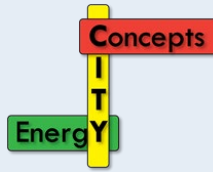
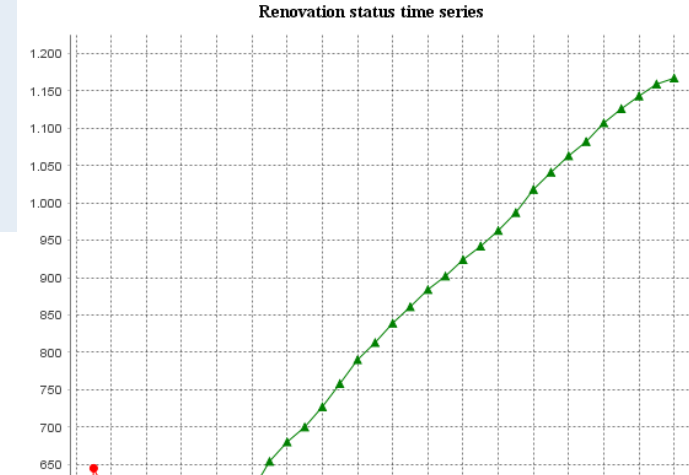


# ..to depict pathways for..

- development scenarios
  - Business as usual (BAU)
    - we keep on doing like we do now
  - Ambitious (AMB)
    - ambitious decisions in terms of climate protection
      - higher renovation rate and quality, renewable sources are preferred, etc.
  - Economic (ECO)
    - as cheap as possible

# ..showing future

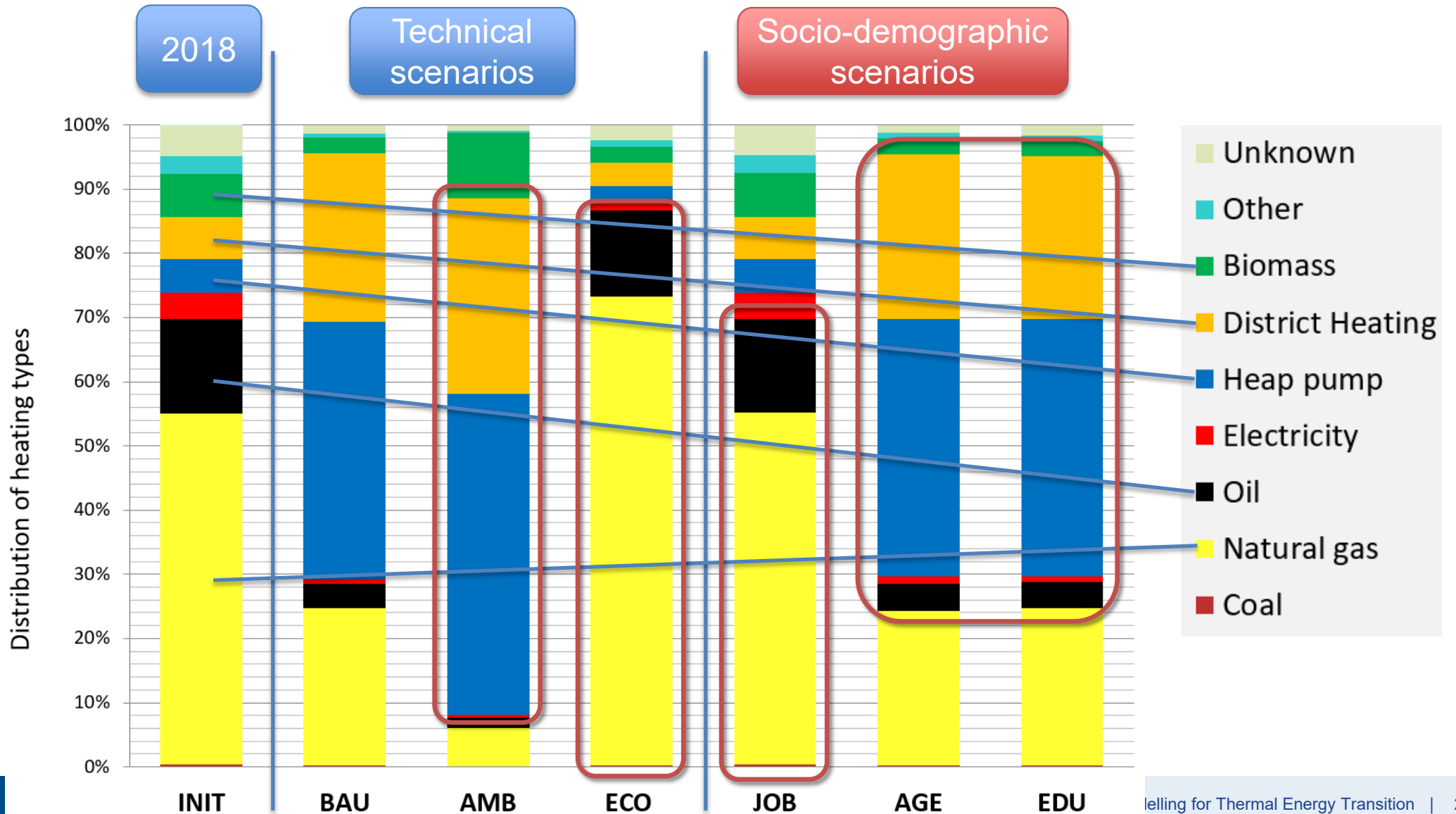
- Renovation status
- Heating system status
- Spatial heat energy demand
- Spatial CO<sub>2</sub> emission
- District heating potential zones



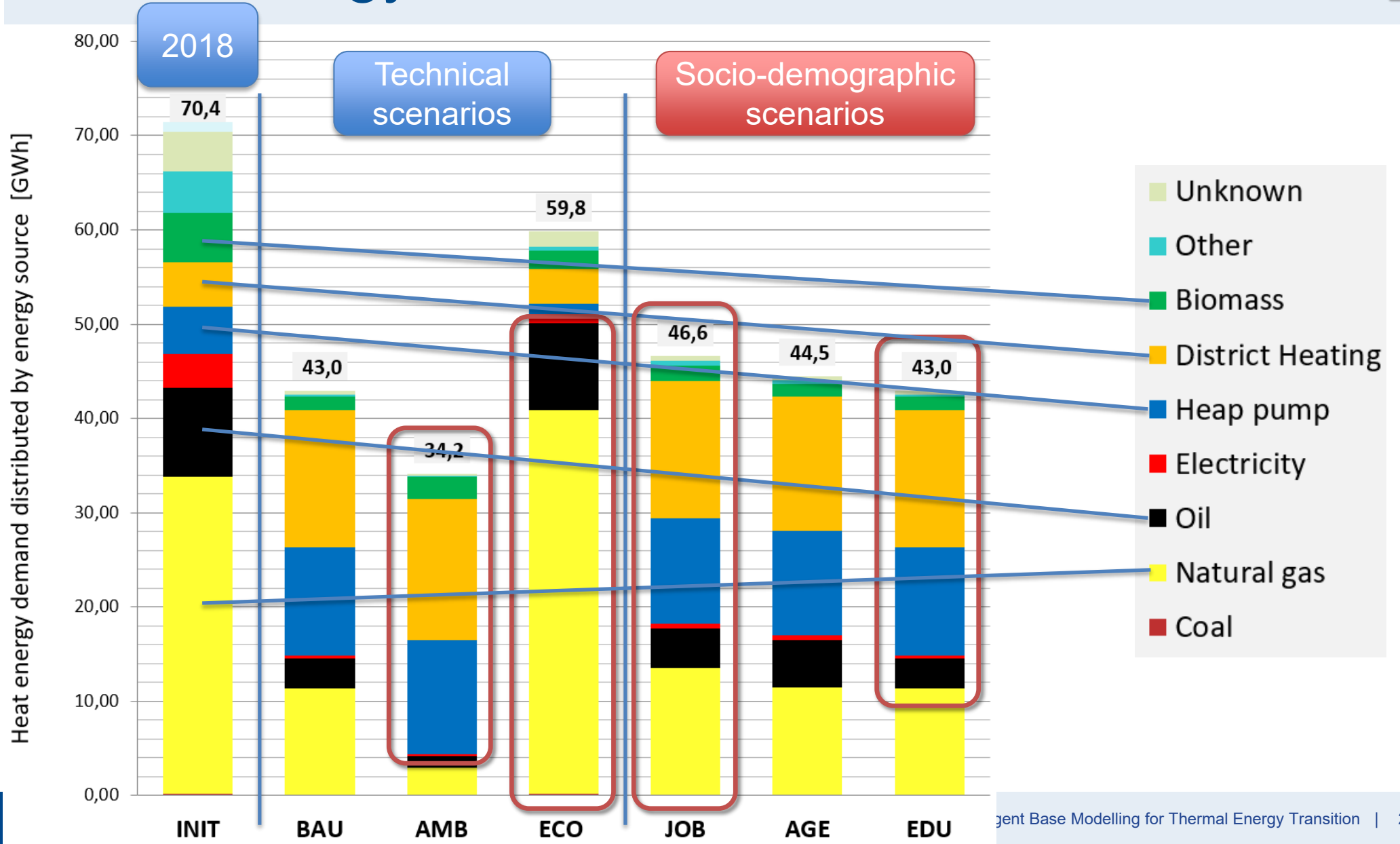
# So? Anything come out?



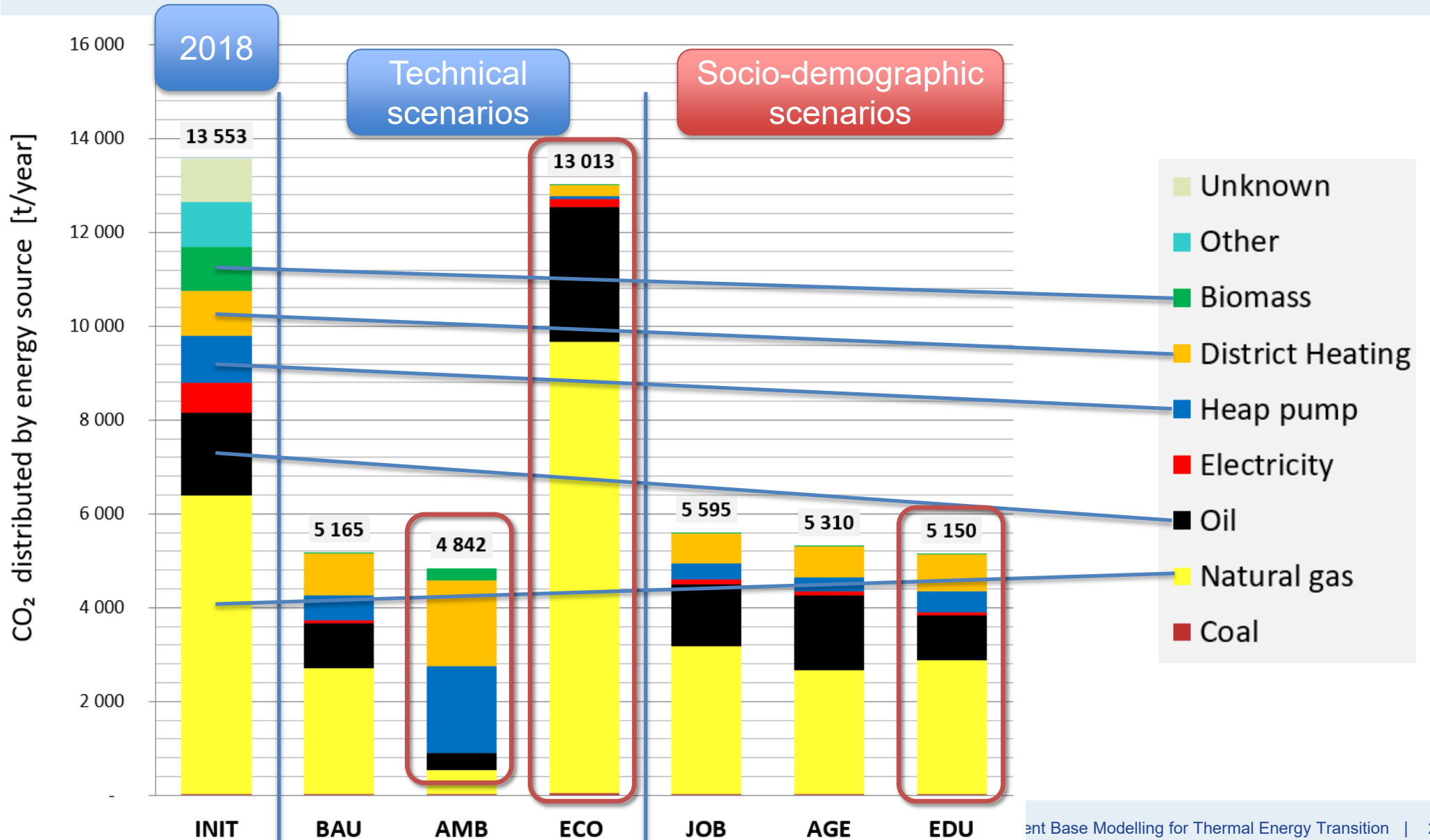
# Heating systems used - 2018 vs. 2050



# Heat energy demand - 2018 vs. 2050



# CO<sub>2</sub> emissions - 2018 vs. 2050



# To cut a long stroy short

# Summary

- **ABM in combination with GIS**
  - powerful tool to simulation interactions in spatial energy planning
- **High potential**
  - to show the influences of planning decisions or public subsidies
  - to model the complex influence of socio-economic effects on spatial energy planning
- **This was the first shot**
  - goal was to have a running and working ABM
  - lot's of ideas for further development
- **And it's a lot of fun..**



please have a look at our

## – Publications

- **Stanzel, L., Scholz, J., & Mauthner, F.** (05 2019). A Spatial Data Analysis Approach for Public Policy Simulation in Thermal Energy Transition Scenarios. Salzburg, Austria: 2nd International Data Science Conference.
- **Nageler, P., Koch, A., Mauthner, F., Leusbrock, I., Mach, T., Hochenauer, C., & Heimrath, R.** (11 2018). Comparison of dynamic urban building energy models (UBEM): Sigmoid energy signature and physical modelling approach. Energy and Buildings(179), 333 - 343. Elsevier B.V. doi:<https://doi.org/10.1016/j.enbuild.2018.09.034>
- **Nageler, P., Mach, T., Heimrath, R., Schranzhofer, H., & Hochenauer, C.** (2017). Generation tool for automated thermal city modelling. Applied Mechanics and Materials.
- **Nageler, P., Zahrer, G., Heimrath, R., Mach, T., Mauthner, F., Leusbrock, I., . . . Hochenauer, C.** (11 2017). Novel validated method for GIS based automated dynamic urban building energy simulations. Energy(139), 142 - 154. Elsevier Ltd. Von <http://dx.doi.org/10.1016/j.energy.2017.07.151>
- **Mauthner, F., Leusbrock, I., Heimrath, R., Nageler, P., Biberacher, M., & Schardinger, I.** (September 2017). Holistic urban energy planning in spatial and temporal resolution – Workflow coupling spatial modeling with dynamic building simulation. 3rd International Conference on Smart Energy Systems and 4th Generation District Heating, Copenhagen, Denmark
- **Ribas, M.** (2016). Holistic urban energy planning in temporal and spatial resolution for the city of Gleisdorf. Grenoble, France: Grenoble Institute of Engineering

# for further information

and our

– Research projects

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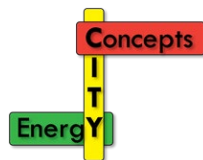
**IDEA TO ACTION**

# Thank you for your attention

The research project *EnergyCityConcepts*  
[www.ecc.aee-intec.at](http://www.ecc.aee-intec.at)

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