Towards an agent-based model of urban electricity sharing

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Motivation

• Centralized energy system susceptible to external shocks
• Increasing utilization of small-scale PV
  – Increased diffusion of EVs expected
  – Cars are parking most of the time and might be used otherwise
• Electricity sharing might cover basic demand during large-scale black-outs
• Experience for such cases is lacking
Aims

• Development of an Agent-based Model (ABM) for the electricity sharing case

• Assumptions
  – Electricity grid & communication network not available (e.g. due to disaster)
  – P2P communication possible (100m)
  – Decentralized PV is available to a certain degree
  – Batteries of electrical vehicles (EVs) as electricity storage
  – Vehicles for transferring electricity to point of demand (apart from movement of people, transport of essential goods (barter trade))
Method: ABM

• Simulation technique
  • Modelling of
    – Individual (agent) behaviour
    – Environment
    – Interactions of agents with each others
    – Interactions with the environment

• (Monte Carlo) Simulation of outcomes
  – Sensitivity to initial conditions
Research agenda

• First step: abstract model in prototypic neighbourhood
  – [Mar-Apr 2014]
  – Emerging dynamics

• Second step: empirics-based model for concrete scenarios
  – How many EVs / PV-Plants necessary
  – How long does it take to diffuse information on (still operating) PV plants
  – Spatial resource distribution, supply/demand
  – ...

Questions addressed in step 1

• Exchange of information on PV-plants in operation (in absence of telecommunication)
  – How long does it take to get overview on situation (“bird-eye view”) via P2P
  – Effect of false information

• Collective dynamics in sharing system with limited supply
  – Different agent strategies: individual decision making vs. mass psychology (orientation to others)
  – Consequences of different cooperation levels
  – Potential problems (e.g. inefficient distribution of PV)
Questions addressed in step 1

• Even if supply/demand-balance, local imbalance might occur
  – Accurate spatial information through local information exchange

• (Preliminary) policy implications
Model prototype

• Implementation in NetLogo
  – Currently ongoing

• Types of ‘agents’
  – Houses (with/without PV)
  – Citizens / EVs

• Interaction
  – Sharing information
  – Sharing PV

• Simple illustration
Figure: Model draft (cut-outs)
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Modeling considerations

• Characteristics of buildings
  – Basic energy demand
  – Domestic PV – yes/no

• Characteristics of EVs
  – Battery capacity
  – Current battery level

• Characteristics of people
  – Information availability
  – Decision making / cooperation strategy
Modeling considerations

• Spatial aspects
  – Urban characteristics like natural barriers, human-made infrastructure, varying population density, etc.
  – Distribution of PV (scattered / compact)

• Abstraction level

• Heterogeneity of agents
  – People are different
  – Thresholds for different behaviours
Open questions / further steps

• Completing prototype
• Analyse emergent properties
  – Inefficiencies
  – Collective dynamics
  – Macro-level outcomes of micro-level decisions
• Empirics-based ABM
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