COMBINING MODELS IN SOCIAL SIMULATION

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Topics

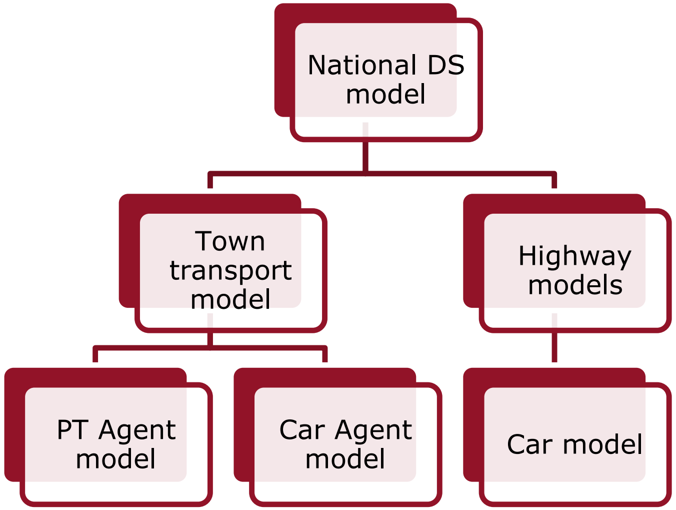
- **Why combining models? Is one model not enough?**
- **How to combine models**
- **Issues when combining models**
- **Examples of combining models**
- **Combining approaches**
- **Example**

Why?

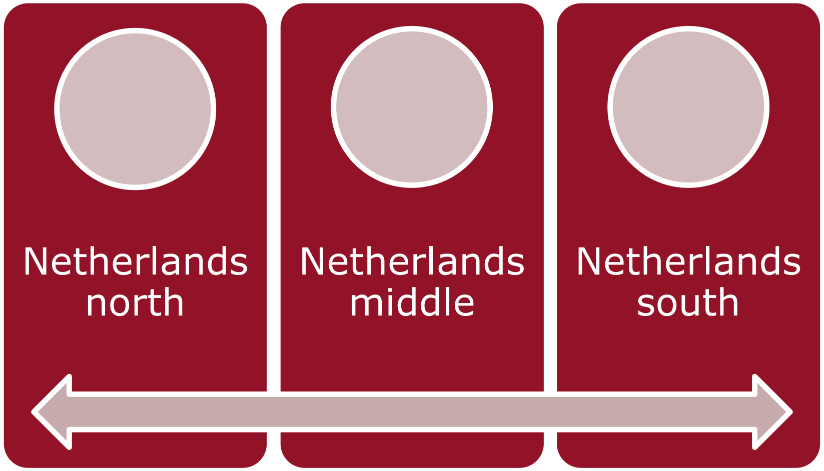
- **Scalability**
  - Use simple models for parts that are not essential and only complex (agent) models for crucial parts
  - Modularize very large models. E.g. use different models for inner city traffic, highway traffic,…
- **Focus of the simulation**
  - Use simple or aggregate models for peripheral phenomena
- **Combining expertise**
  - Urban development brings together many disciplines with their own models
- **Interdisciplinarity**

How to combine models

- **Vertical combination**



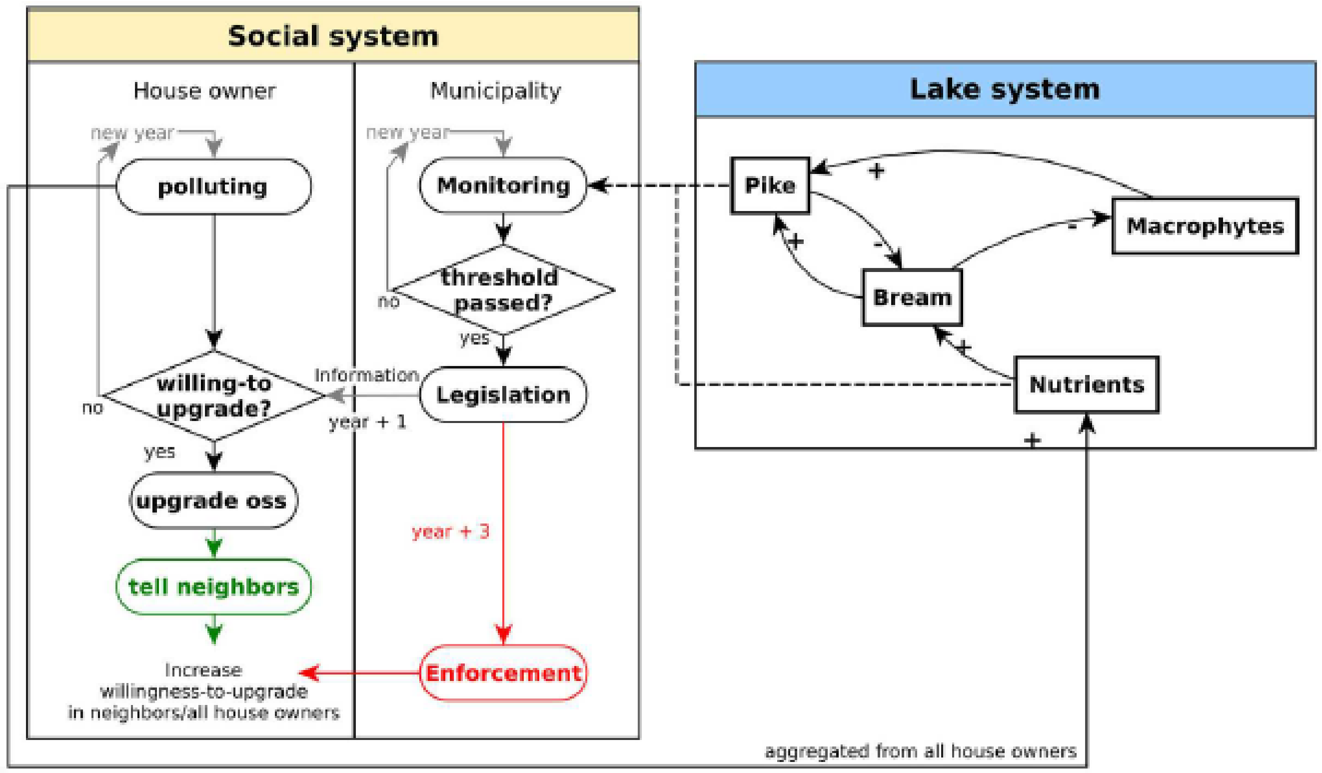
- **Horizontal combination**



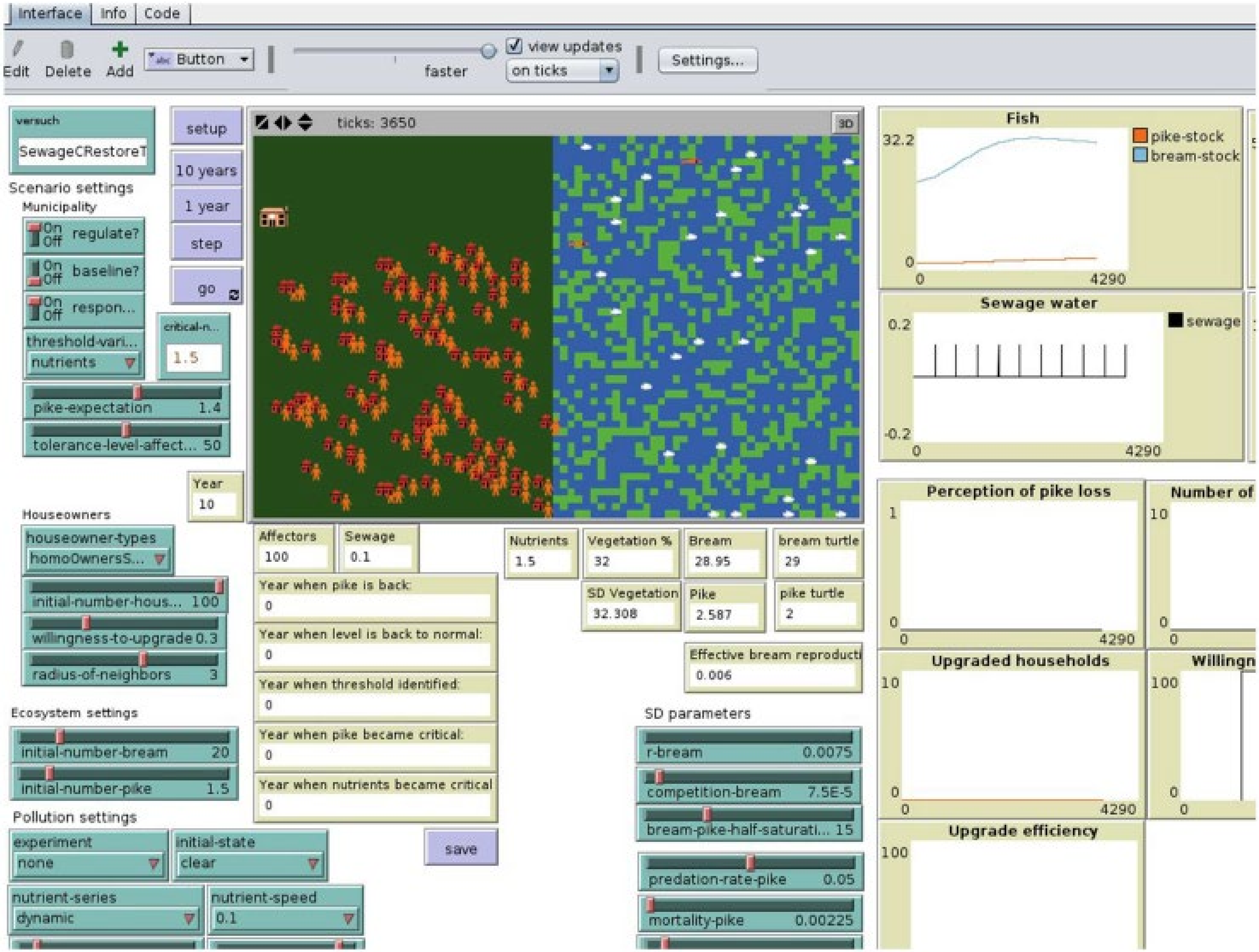
Some issues

- **Time scale**
- **Aggregation levels**
- **Assumptions**
- **Dependencies (access to parameters and timing)**
- **Purpose of the models**

Example 1:
Socio ecological models for lake restoration



Netlogo as main platform



Lake quality

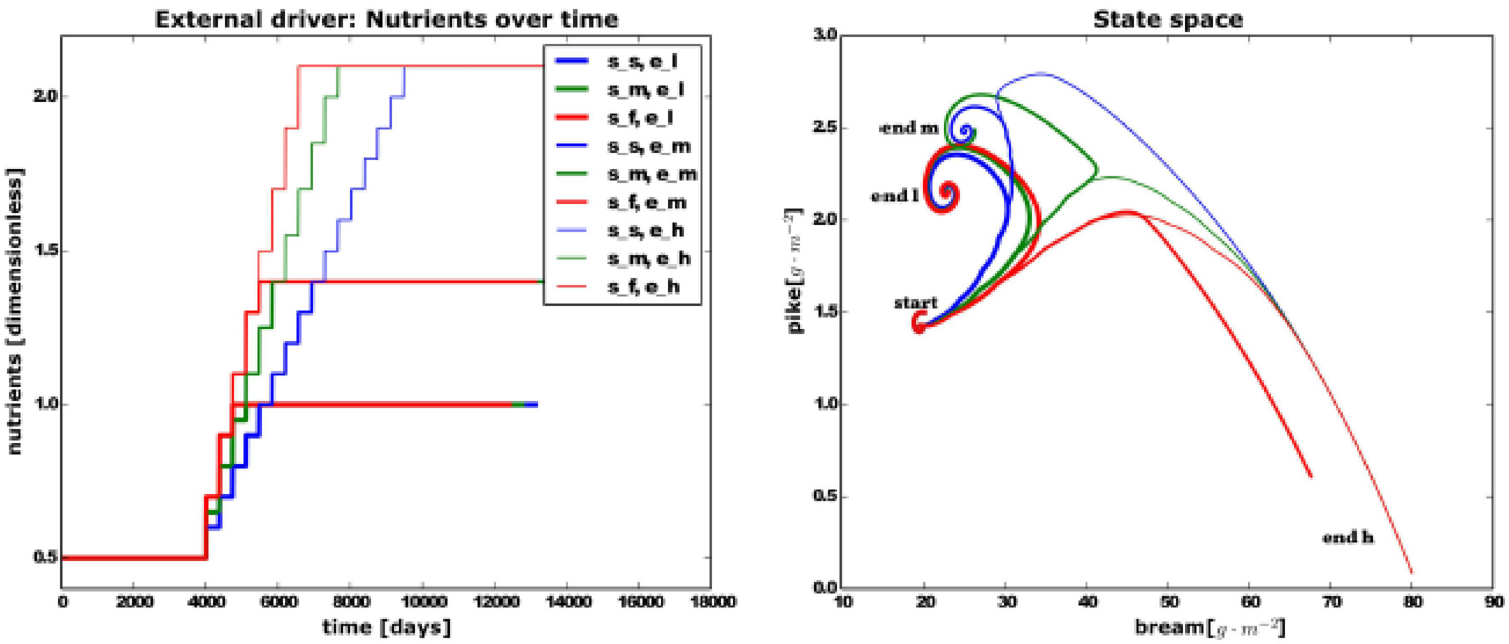


FIGURE 5 | Left: Nutrient time series as driver for scenarios, at three rates (speed: slow, medium, high), and three different destination levels (end: low, medium, high), showing results from nine simulations in total. Right: The resulting fish populations in the state space. At the lowest nutrient levels, the resulting fish state is independent of the rate of change. But in the intermediate nutrient level, fish populations driven by the fastest increase (red) experience pike reduction while at slower rates pike increases can be observed. At the highest nutrient level, all fish simulations result in the low-pike-state.

Relation between sewerage upgrade and lake quality

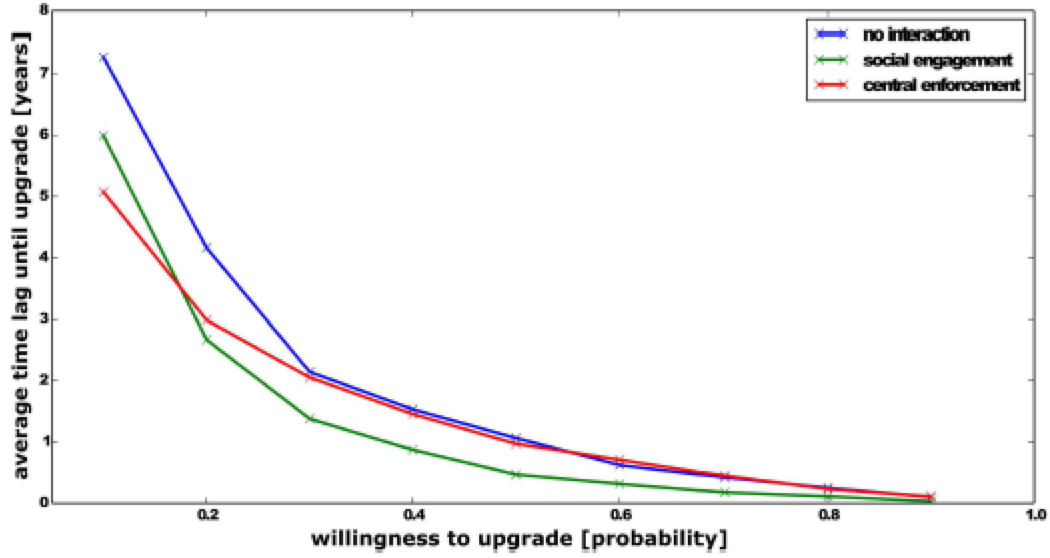


FIGURE 6 | Three scenarios showing the aggregated, average time that is necessary for private house owners to upgrade their sewage system over a range of initial values for "willingness-to-upgrade."

Scenario	Willingness-to-upgrade	Social lag [years]	Ecological lag [years]
No Interaction	0.1	9.6 ± 0.9	34.6 ± 2.8
	0.2	4.2 ± 0.4	9.7 ± 4.8
Social engagement	0.1	5.7 ± 0.4	21.4 ± 2.5
	0.2	**2.5 ± 0.3**	**3.9 ± 0.3**
Central enforcement	0.1	**4.9 ± 0.3**	**19.9 ± 2.1**
	0.2	3 ± 0.3	4.8 ± 1.9

Bold entries mark the minimal time lag compared to the alternative interaction scenarios tested.

Example 2: Climate change

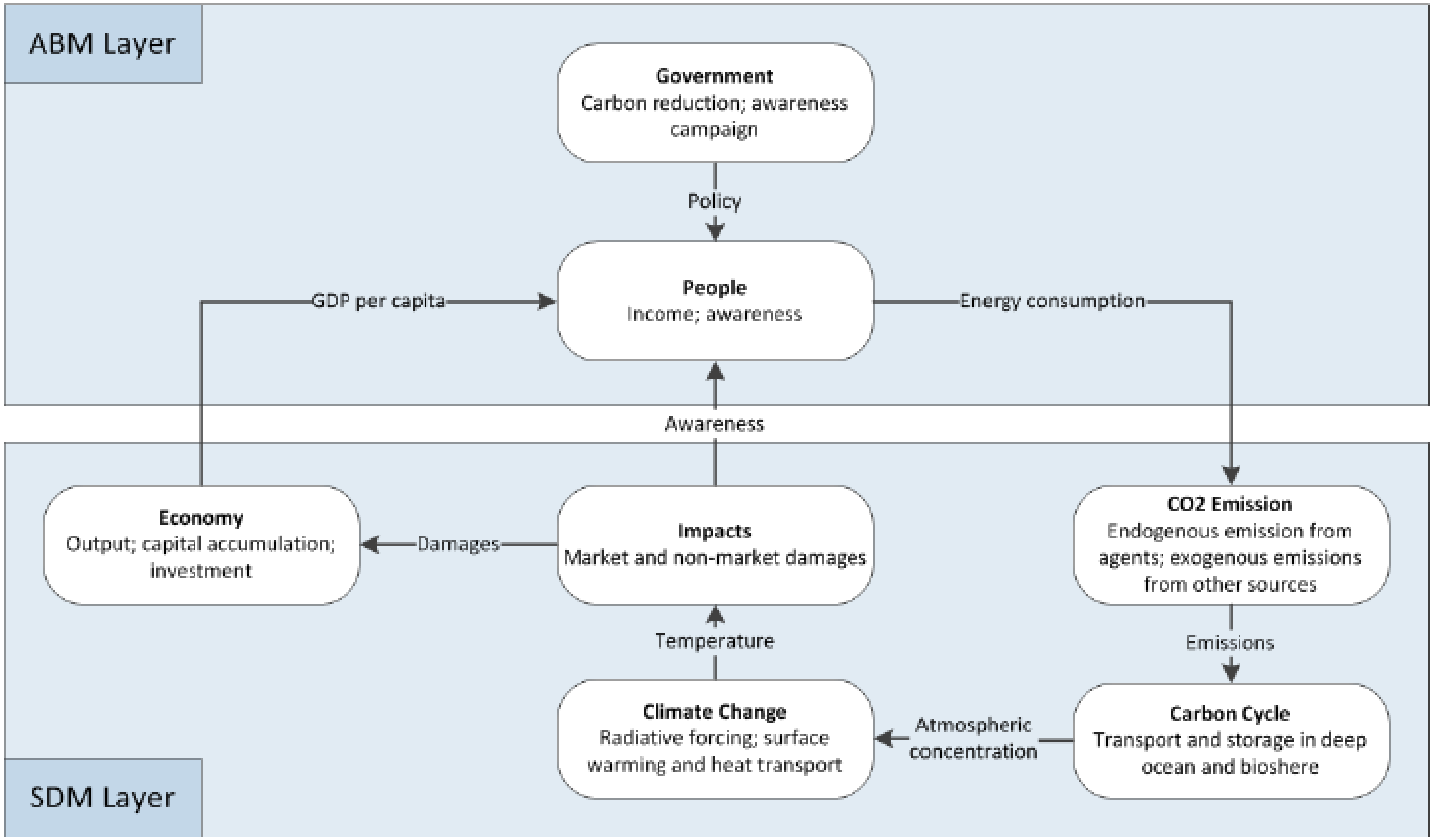


Figure 1: Sector Map of HCAM (SD model layer based on Fiddaman 1997)

Overall model

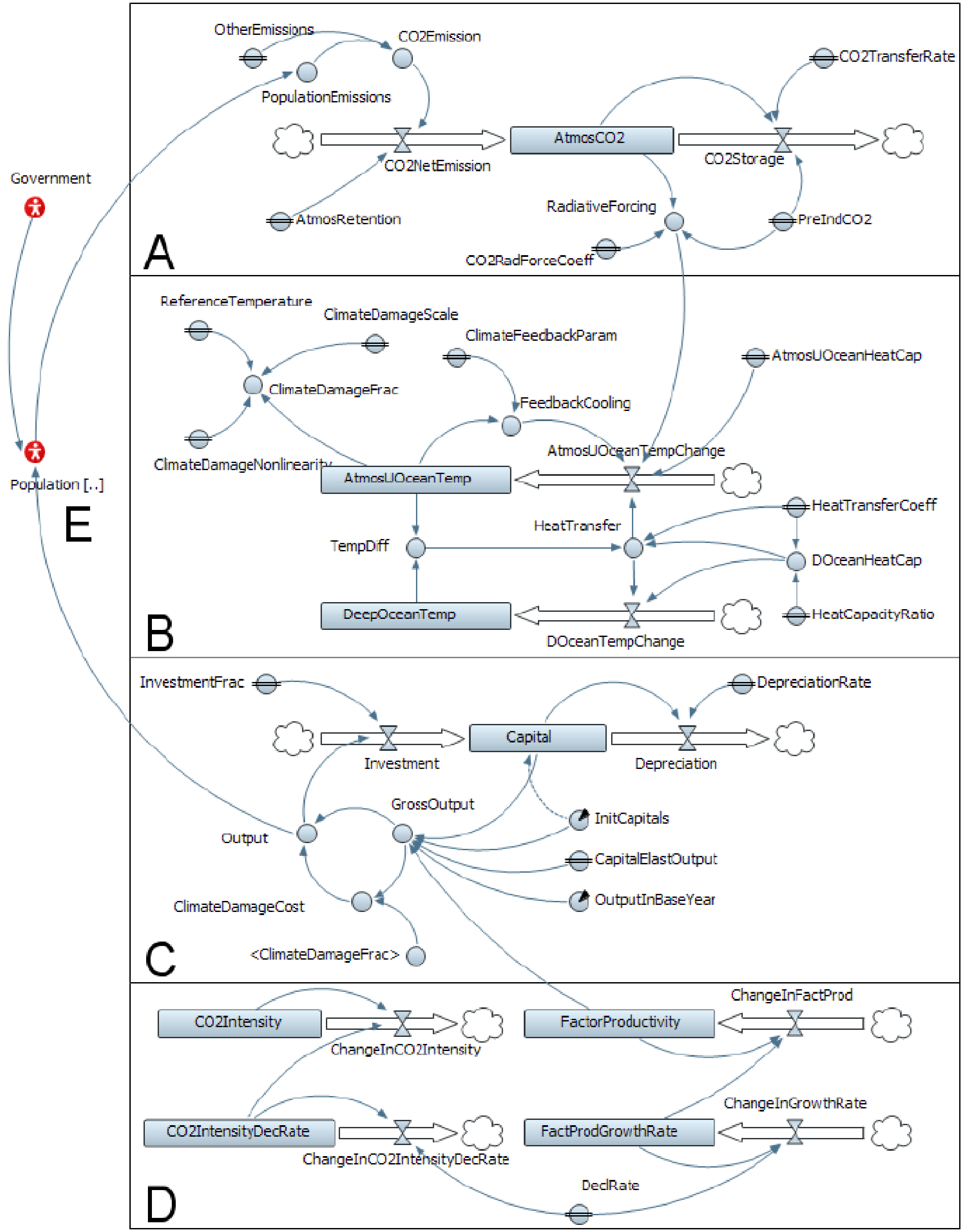


Figure 2: Overall causal structure of the HCAM

Cognitive factors and social connections

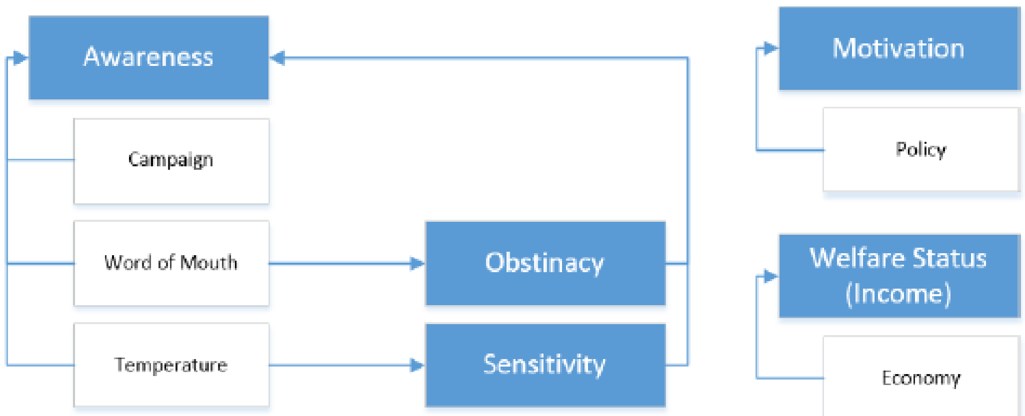
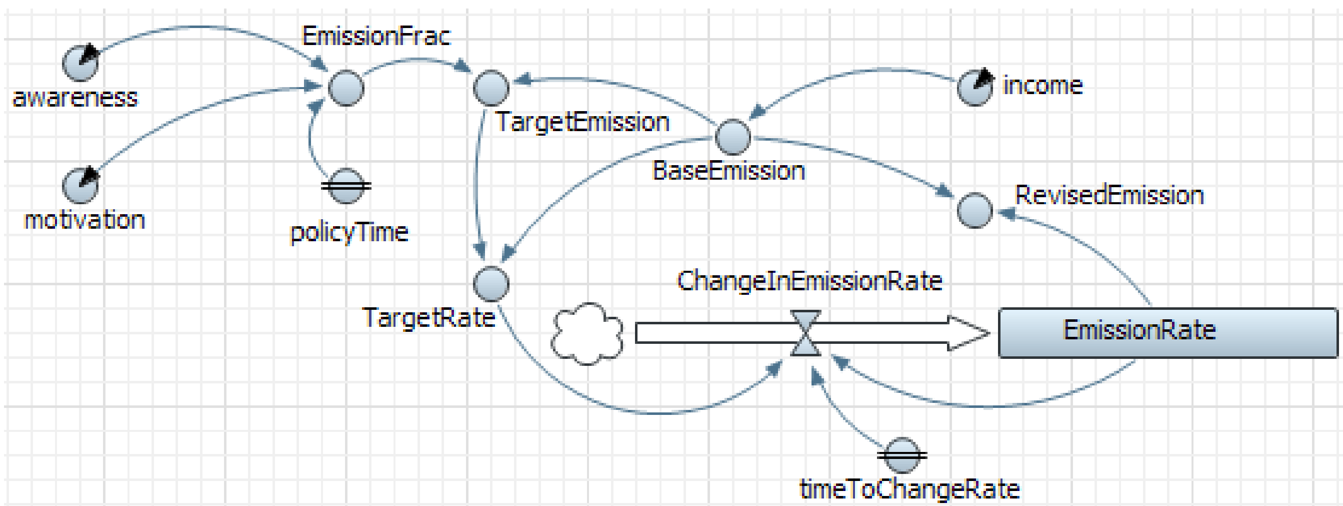
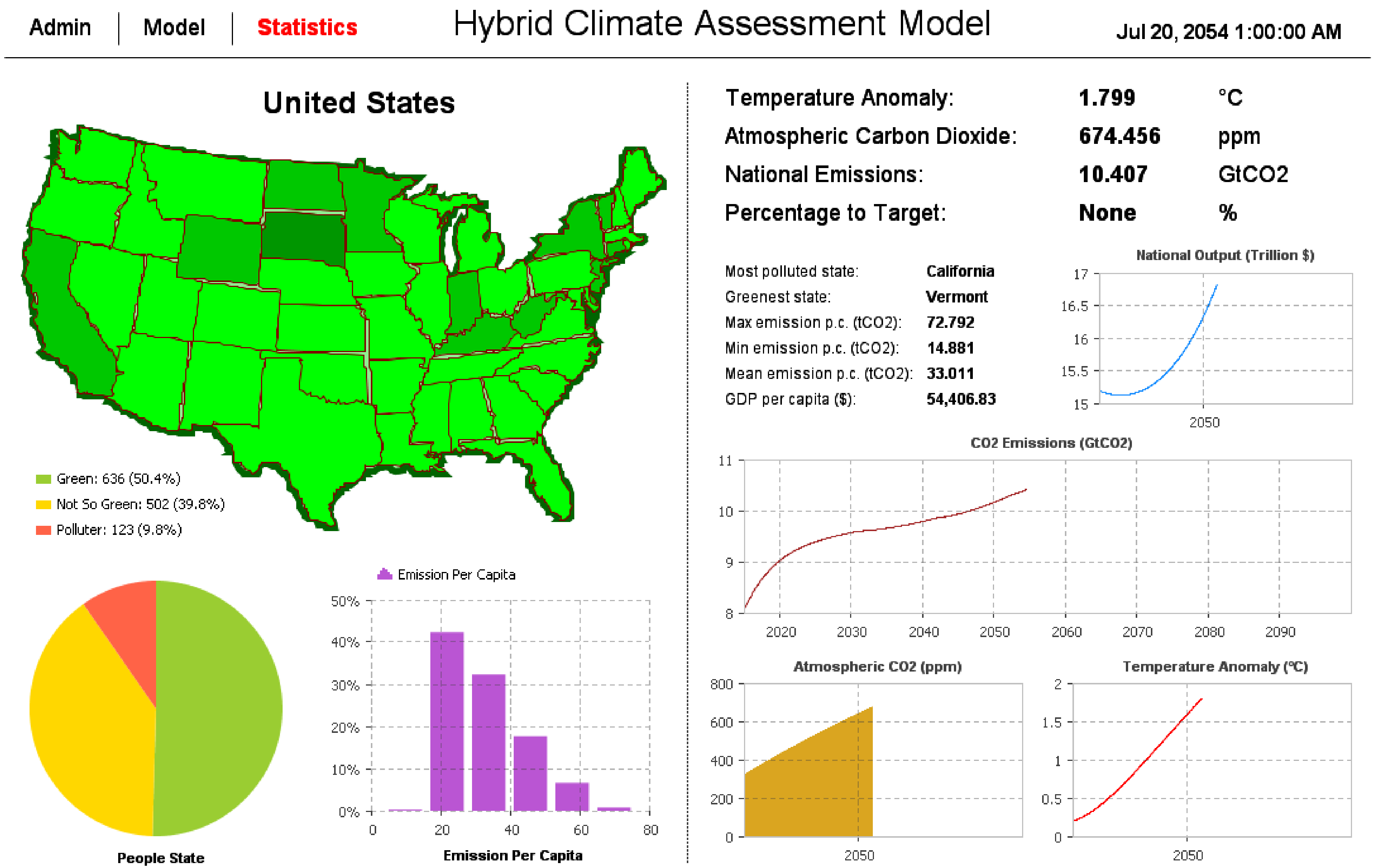


Figure 4: Mental model attributes (blue boxes) with external influences (white boxes)



Interface


Admin
Model
Statistics
Hybrid Climate Assessment Model
Jul 20, 2054 1:00:00 AM
United States
Green: 636 (50.4%)
Not So Green: 502 (39.8%)
Polluter: 123 (9.8%)
People State
Emission Per Capita
50%
40%
30%
20%
10%
0%
0 20 40 60 80
Emission Per Capita
Temperature Anomaly: 1.799 °C
Atmospheric Carbon Dioxide: 674.456 ppm
National Emissions: 10.407 GtCO2
Percentage to Target: None %
Most polluted state: California
Greenest state: Vermont
Max emission p.c. (tCO2): 72.792
Min emission p.c. (tCO2): 14.881
Mean emission p.c. (tCO2): 33.011
GDP per capita ($): 54,406.83
National Output (Trillion $)
17
16.5
16
15.5
15
2050
CO2 Emissions (GtCO2)
11
10
9
8
2020 2030 2040 2050 2060 2070 2080 2090
Atmospheric CO2 (ppm)
800
600
400
200
0
2050
Temperature Anomaly (°C)
2
1.5
1
0.5
0
2050

Example 3:
Feet and mouth disease in Australia

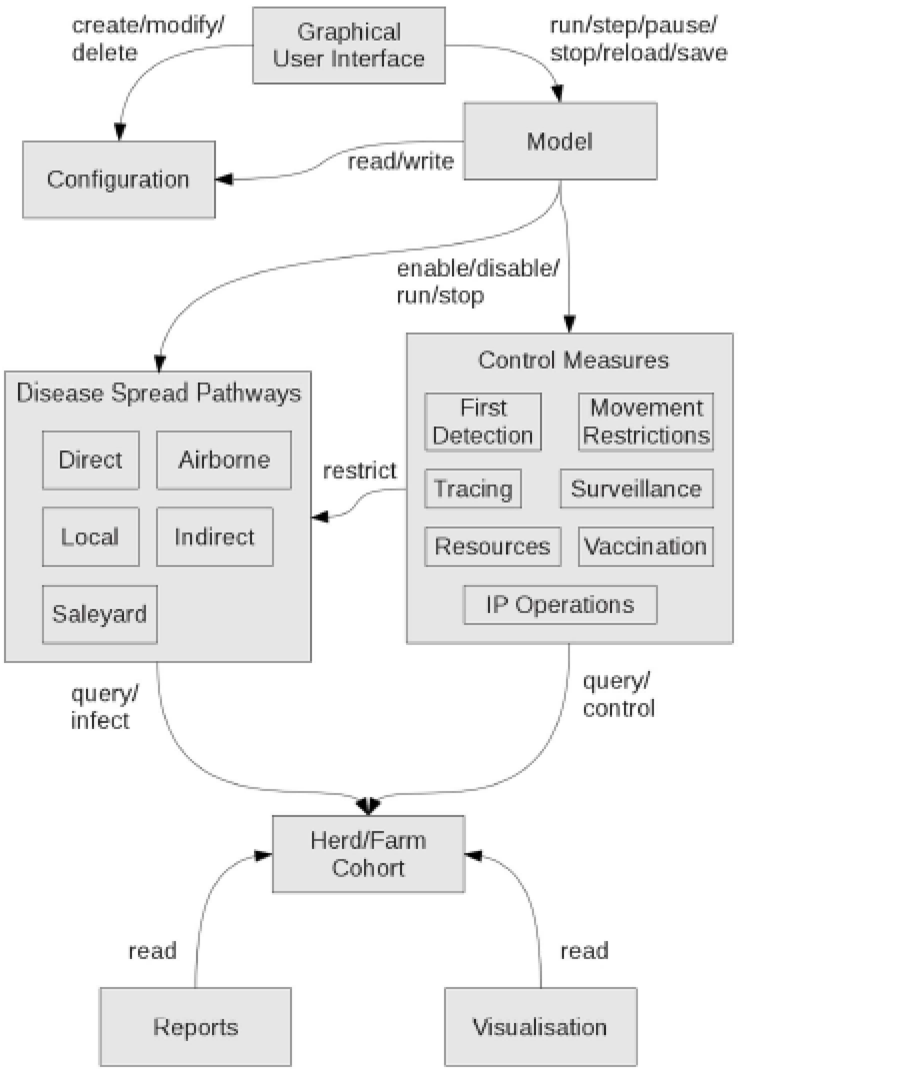


FIGURE 6 | AADIS subsystems.

Agent model includes SD model

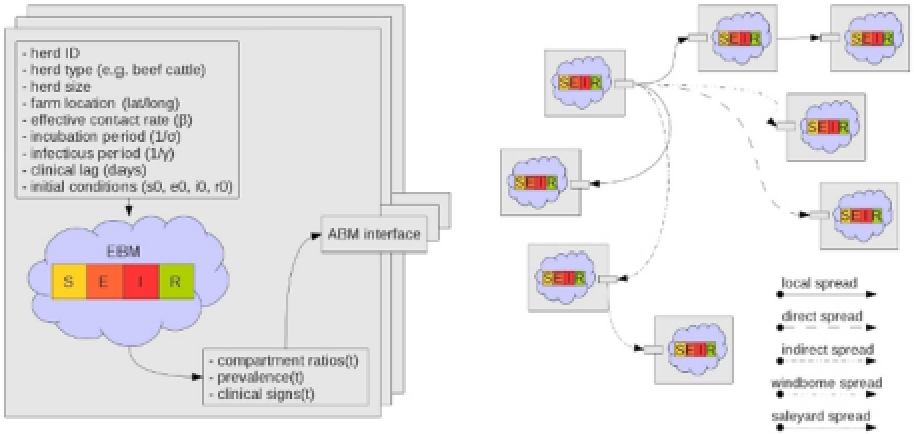


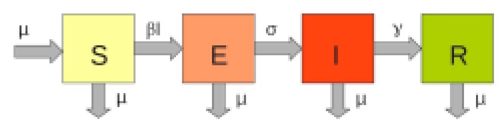
FIGURE 2 | Each herd instance has a customized SEIR ODE-based EBM. The ABM stochastically establishes infection connection paths between herds (Bradhurst et al., 2013).

$$\frac{dS}{dt} = \mu - \beta I S - \mu S$$

$$\frac{dE}{dt} = \beta I S - \mu E - \sigma E$$

$$\frac{dI}{dt} = \sigma E - \mu I - \gamma I$$

$$\frac{dR}{dt} = \gamma I - \mu R$$



where S = proportion of the herd that are susceptible
E = proportion of the herd that are exposed
I = proportion of the herd that are infectious
R = proportion of the herd that are recovered
$\frac{1}{\mu}$ = average natural lifespan of the host, (μ = birth rate = natural mortality rate)
β = effective contact rate (contact rate × transmission probability)
$\frac{1}{\sigma}$ = average duration of the latent period, (σ = progression rate from exposed to infectious)
$\frac{1}{\gamma}$ = average duration of the infectious period, (γ = recovery rate)

FIGURE 1 | ODE system used by AADIS to model within-herd spread of FMD.

Example 4: Urban shrinkage

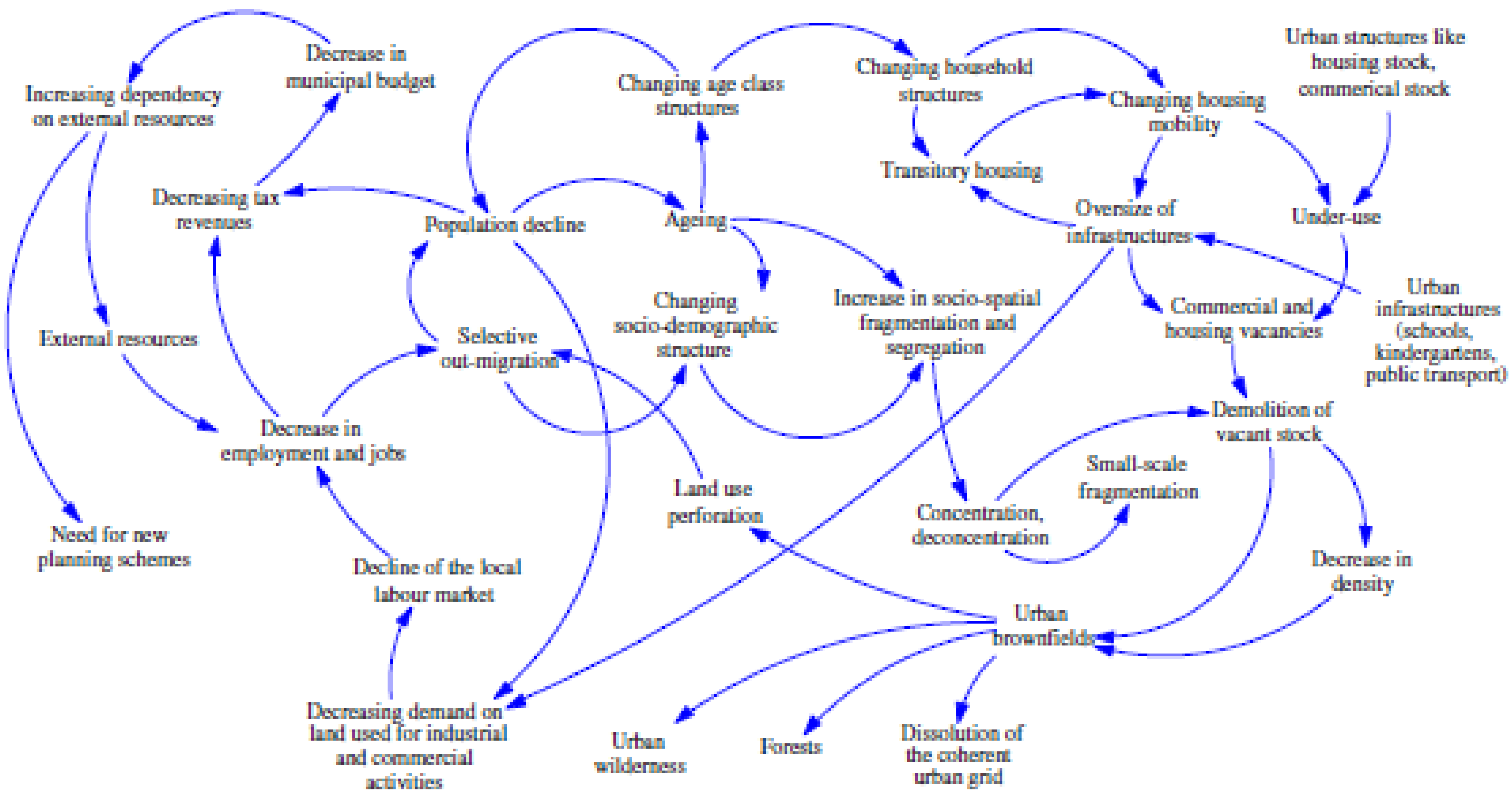


Fig. 1. A conceptual relational model that displays the causal relationships between the variables of shrinkage (namely its drivers, processes and impacts) which are shown in Table 1 (content: A. Haase, D. Rink; model: D. Haase).

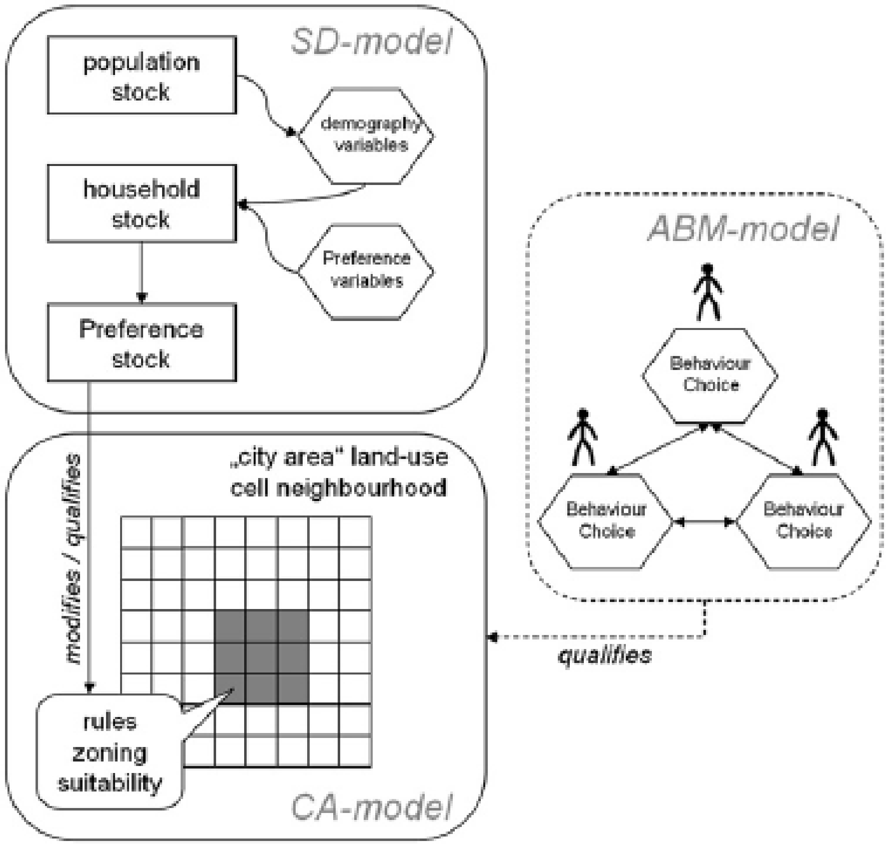
Features to be modeled

Table 3
Features of urban shrinkage and respective suitable modelling approaches.

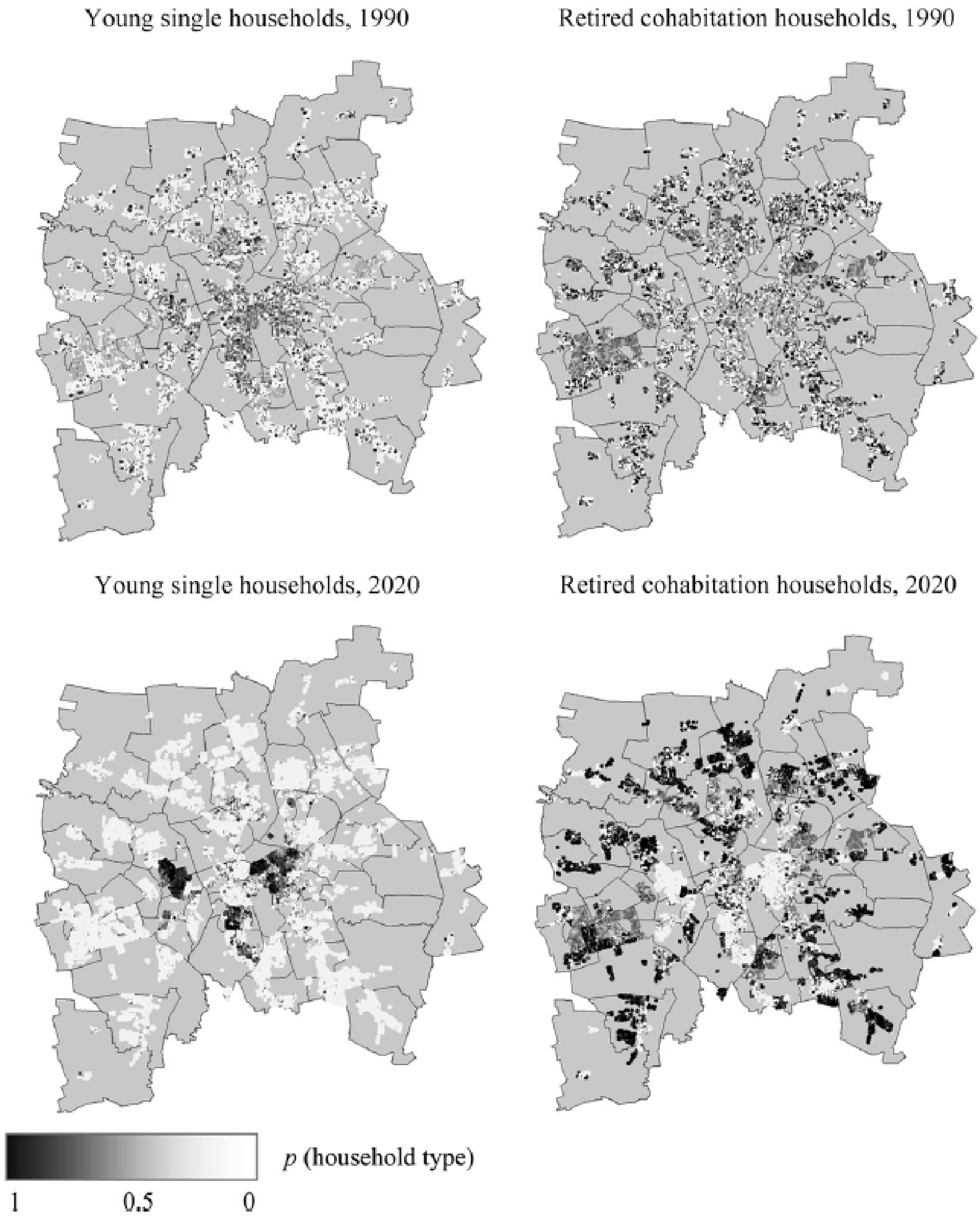
Features and processes of urban shrinkage	Modelling approach	Data availability	Spatial resolution of data	Advantages
Population loss	SD[a]	Annual	Local Municipal Districts	• Large stocks which create demands on space but whose dynamics can be modelled neglecting the space
Socio-demographic structure		Annual	Local Municipal Districts	• Fast processing • Many existing numeric models
Households and forms of cohabitation				
Housing demand	SD[a] or ABM[c]	Annual	Aggregated value at city level	• Creation of stocks and flows of land demand for a population (eg households)
Segregation	ABM[c]	Annual	Local municipal districs	• Captures individual decision-making processes
Urban structures: housing stock, commercial land	CA[b]	No time restriction	Remote sensing data, biotope maps, Google, ATKIS[a]	• Properties of the space • Neighborhood relations • Accessibility dependencies • Density as property of space
Residential and commercial vacancy		Irregular	Estimates by city govern-ment and housing companies	
Perforation		No time restriction	Derived value from land-use	
Underuse of infrastructure		Annual	Database of municipal water, enegry and transport supply	
Decline of the labor market	SD[a]	Annual	Local municipal districs	• Cumulative stocks • Fast processing necessary • Many existing statistical and econometric models as knowledge base
Decline of tax revenues		Annual	Aggregated value at city level	
Decrease of municipal budget		Annual	Aggregated value at city level	
Need for new planning schemes and governance structures	ABM[c]	Irregular	Both local municipal districs and aggregated at city level	• Captures individual and collective decision-making processes • Need for comprehensive "agent profiles" to depict cases such as the prisioner's dilemma or collaboration

[a] System dynamics.
[b] Cellular automata.
[c] Agent-based model.

Connection between models

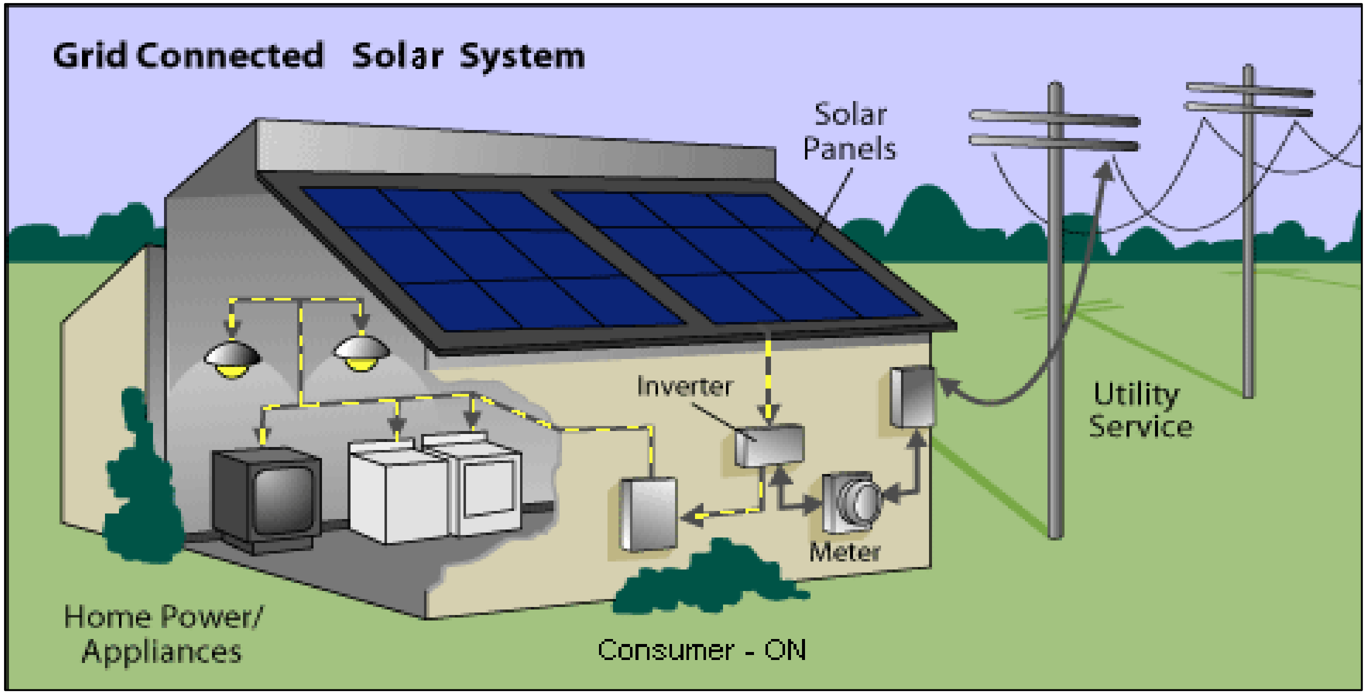


Output


Young single households, 1990
Retired cohabitation households, 1990
Young single households, 2020
Retired cohabitation households, 2020
1
0.5
0
p (household type)

Example 5: sustainable energy

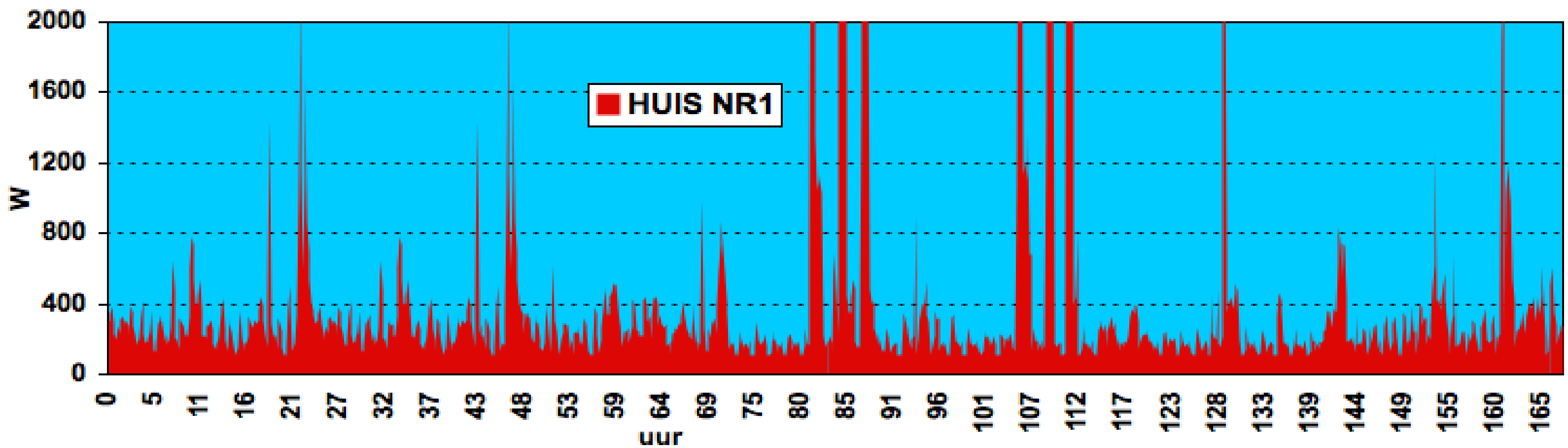
Electricity networks are changing

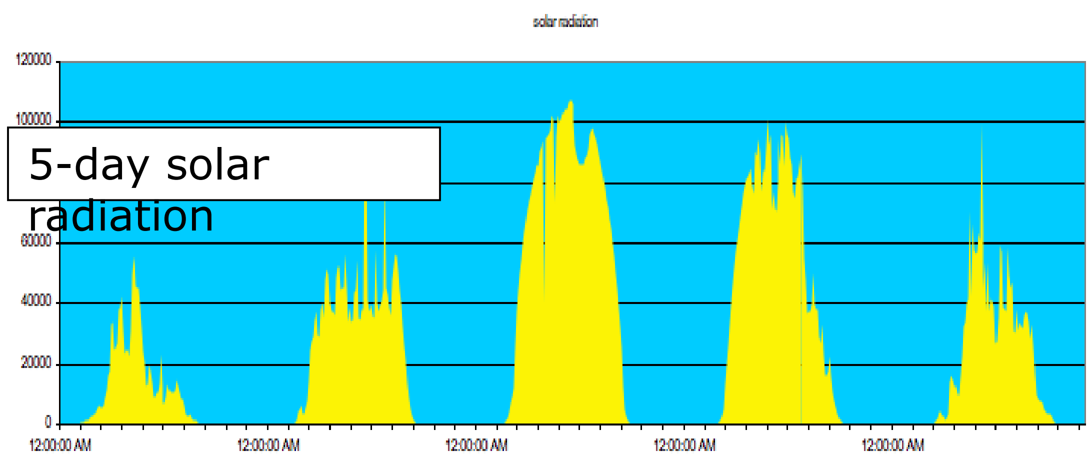


- Solar panels
- Wind generators
- Combined heat and power (CHP)
- E-vehicles

Consumption & generation patterns

Individual power usage is highly variable



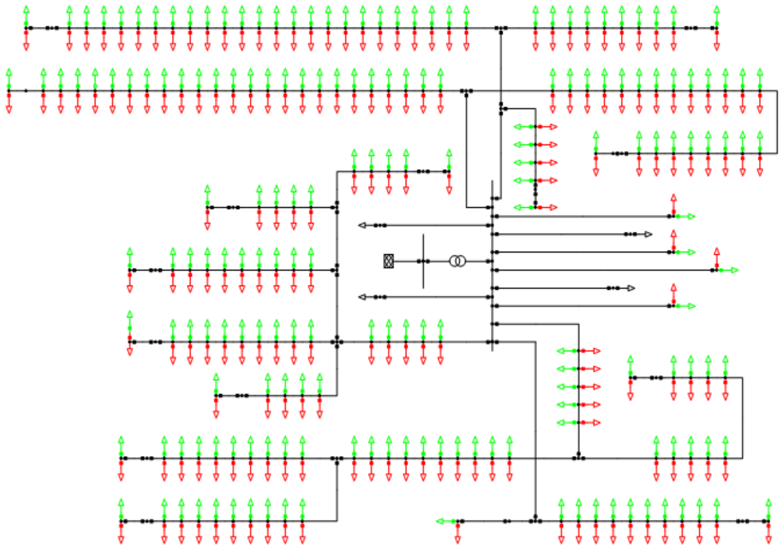


Solar energy may be available during hours of low consumption.

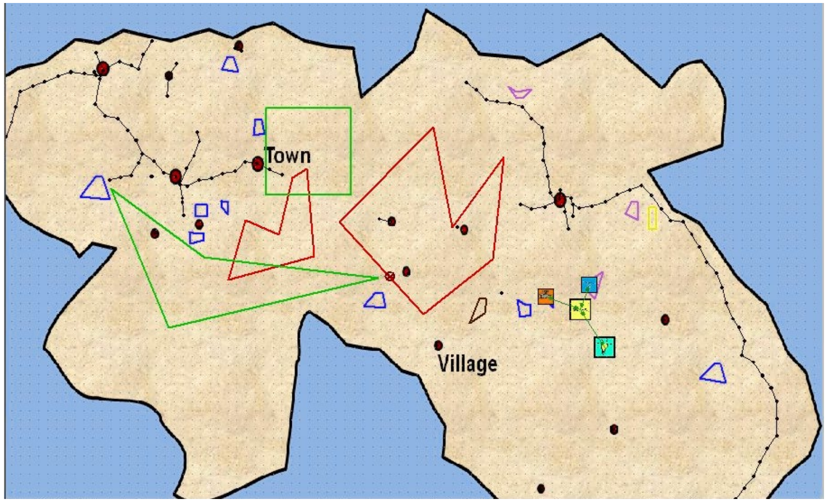
Optimizing decentral generation

- As consumers install power generation units, the network cables may be overloaded.
- What is the maximum distributed generation within network load constraints?
  - Linear programming model
  - Houses close to grid connection are favoured: fairness rules

Projects with KEMA DNV



Additional connections

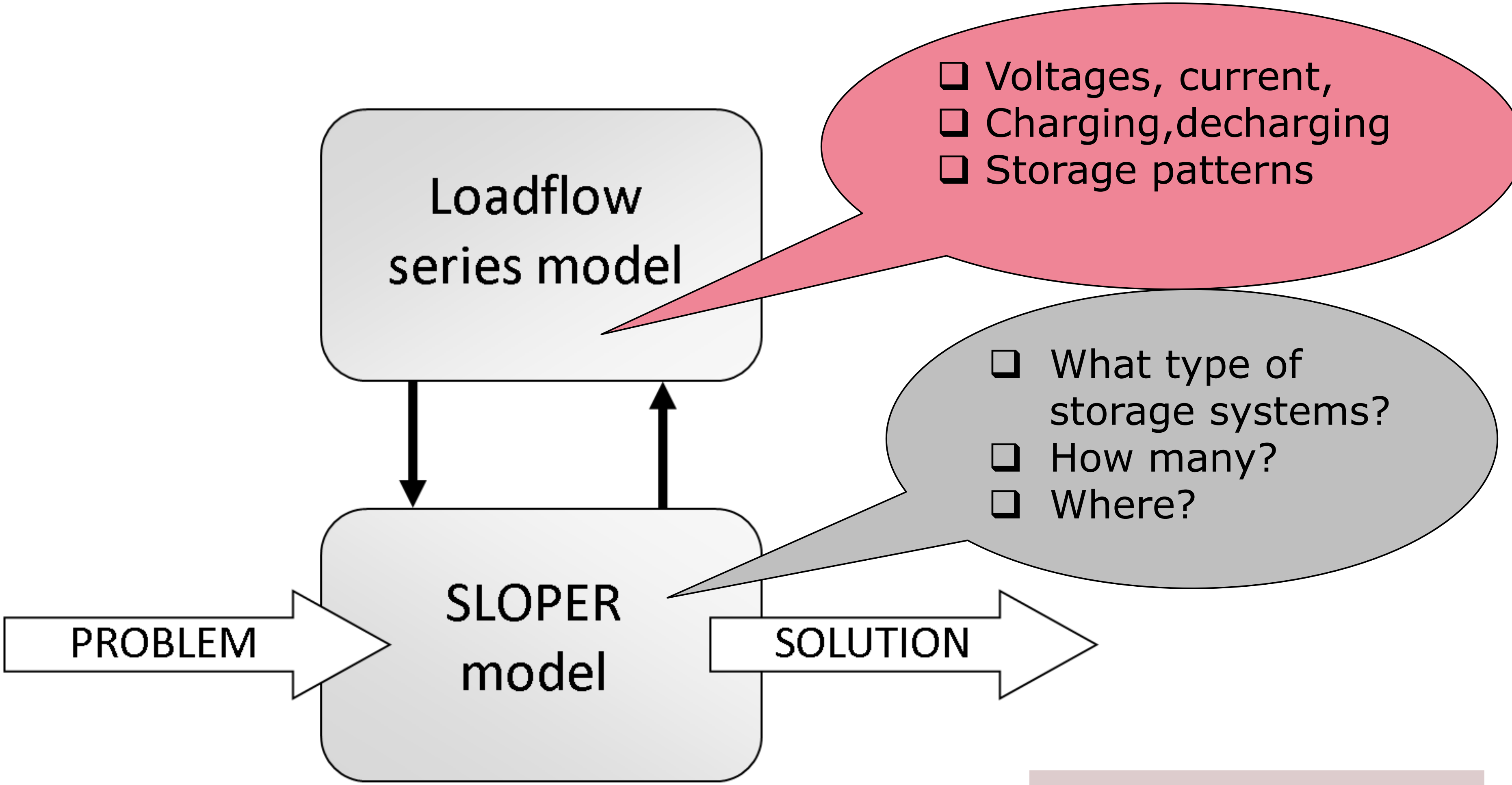


- Optimal investment decisions
- Integer linear programming
- Search heuristics

Why storage system helps

- Storing decentrally generated energy
- Prevent overloading
- Prevent voltage drops
- Power delivery in case of black-out
- Trading

How to use storage systems: Decomposition model



Decentral generation and consumption fixed!

Scheduling in smart grids

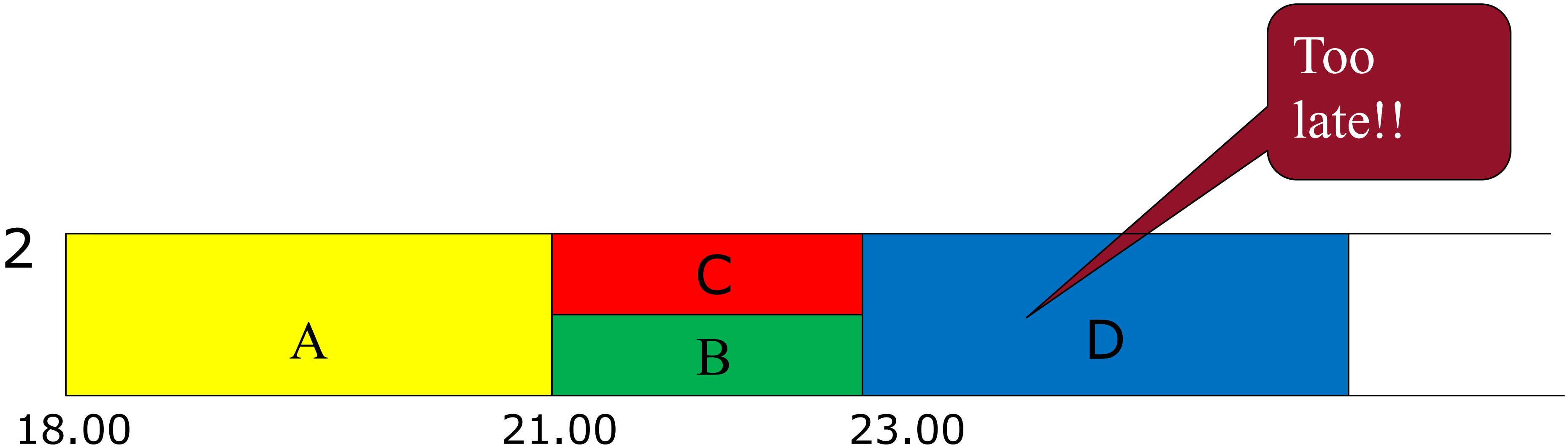
•Street has available load capacity 2

Job	duration	Req. cap	Request time	Deadline
 A	3 hrs	2	18.00	8.00
 B	2 hrs	1	19.00	00.30
 C	2 hrs	1	19.00	00.30
 D	3 hrs	2	19.30	23.00

Scenario 1

- First-come-first served
- No preemption

	duration	Req. cap	Request time	Deadline
A	3 hrs	2	18.00	8.00
B	2 hrs	1	19.00	00.30
C	2 hrs	1	19.00	00.30
D	3 hrs	2	19.30	23.00



Scheduling in smart grids

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Job	Duration	Req. cap	Request time	Deadline
 A	3 hrs	2	18.00	8.00
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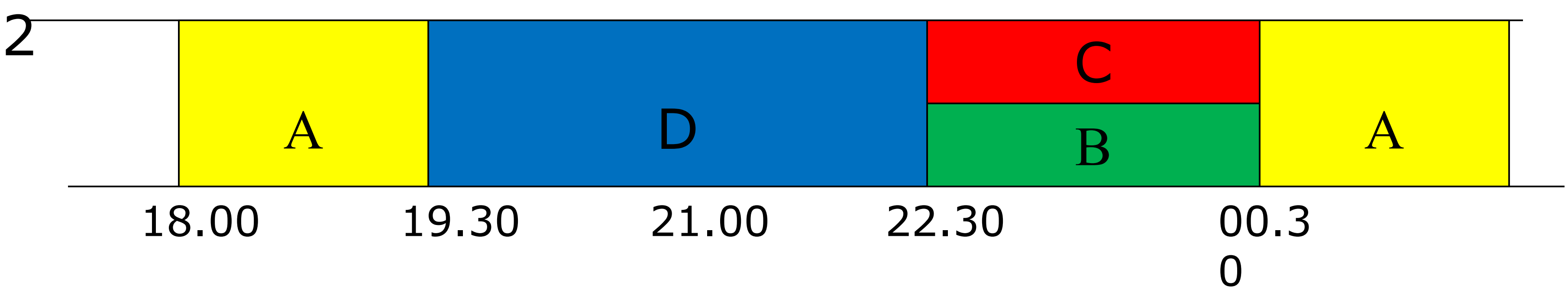
 C	2 hrs	1	19.00	00.30
 D	3 hrs	2	19.30	23.00

Scenario 2

- FCFS not mandatory
- Preemption is allowed for charging e-vehicles

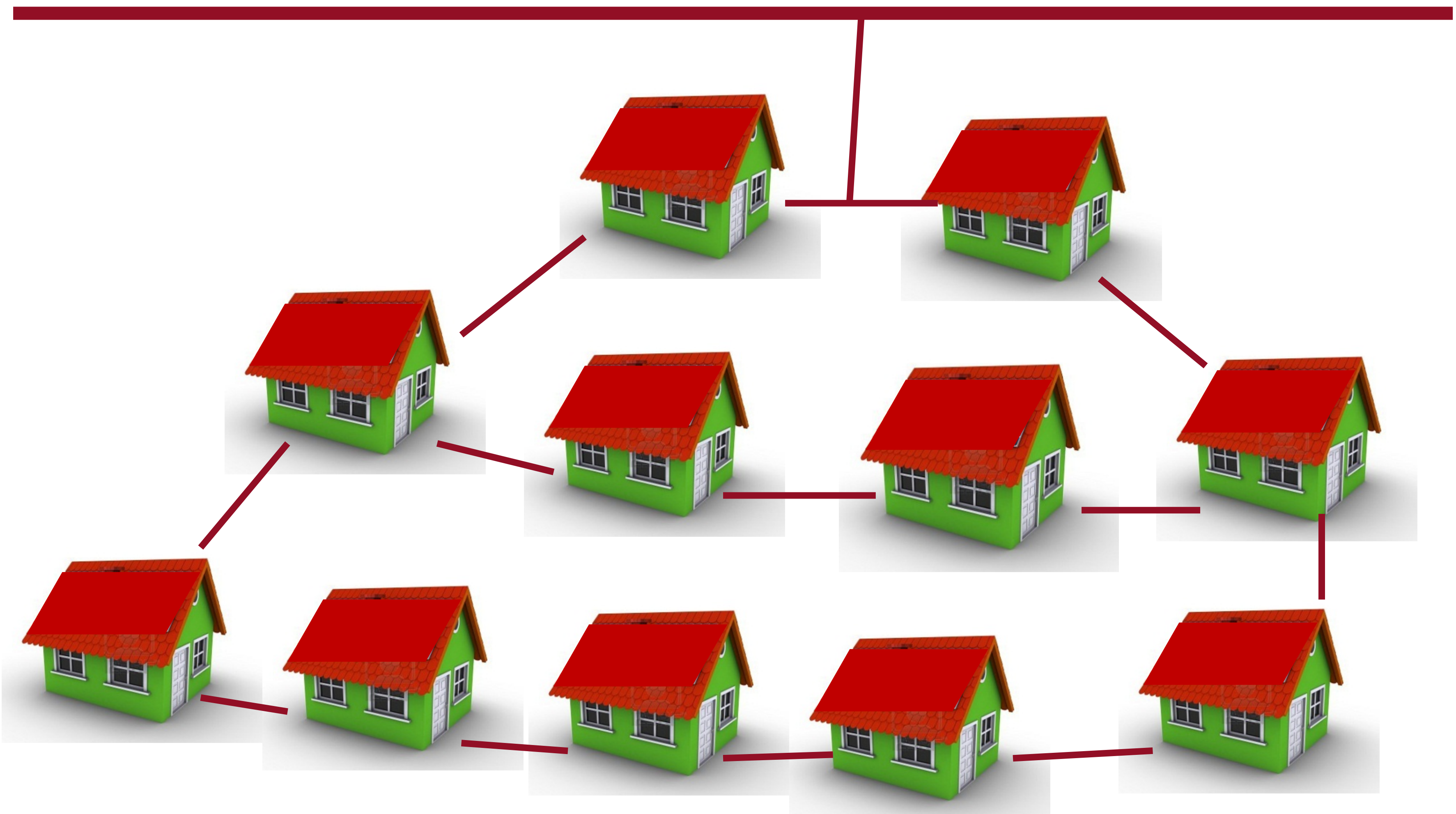
Job	duration	Req. cap	Request time	Deadline
A	3 hrs	2	18.00	8.00
B	2 hrs	1	19.00	00.30
C	2 hrs	1	19.00	00.30
D	3 hrs	2	19.30	23.00



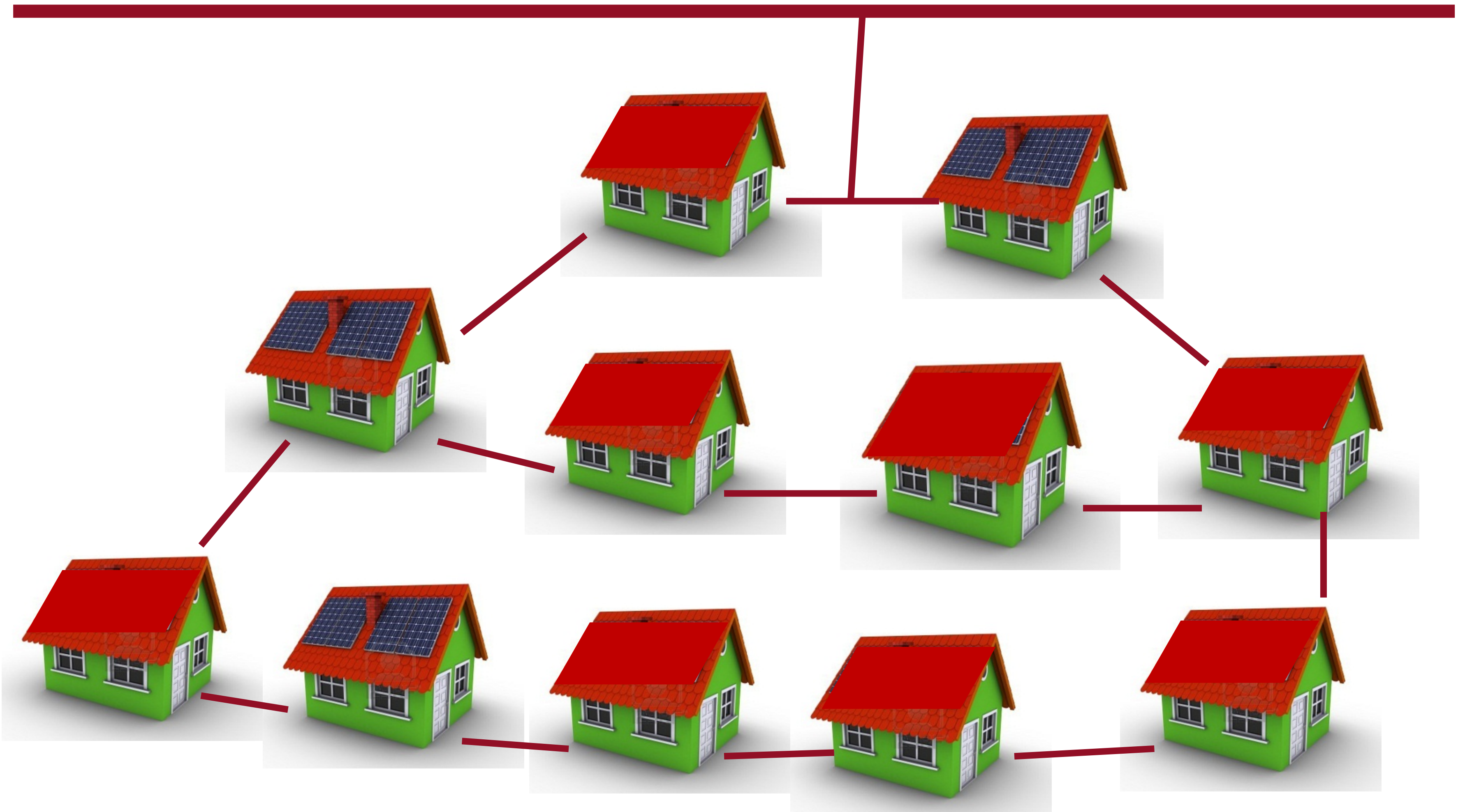
Energy is used by People

1. People take decisions based on decisions of other people
2. Small changes in behavior of one person can have big consequences
3. Statistics do not always work

Electricity network

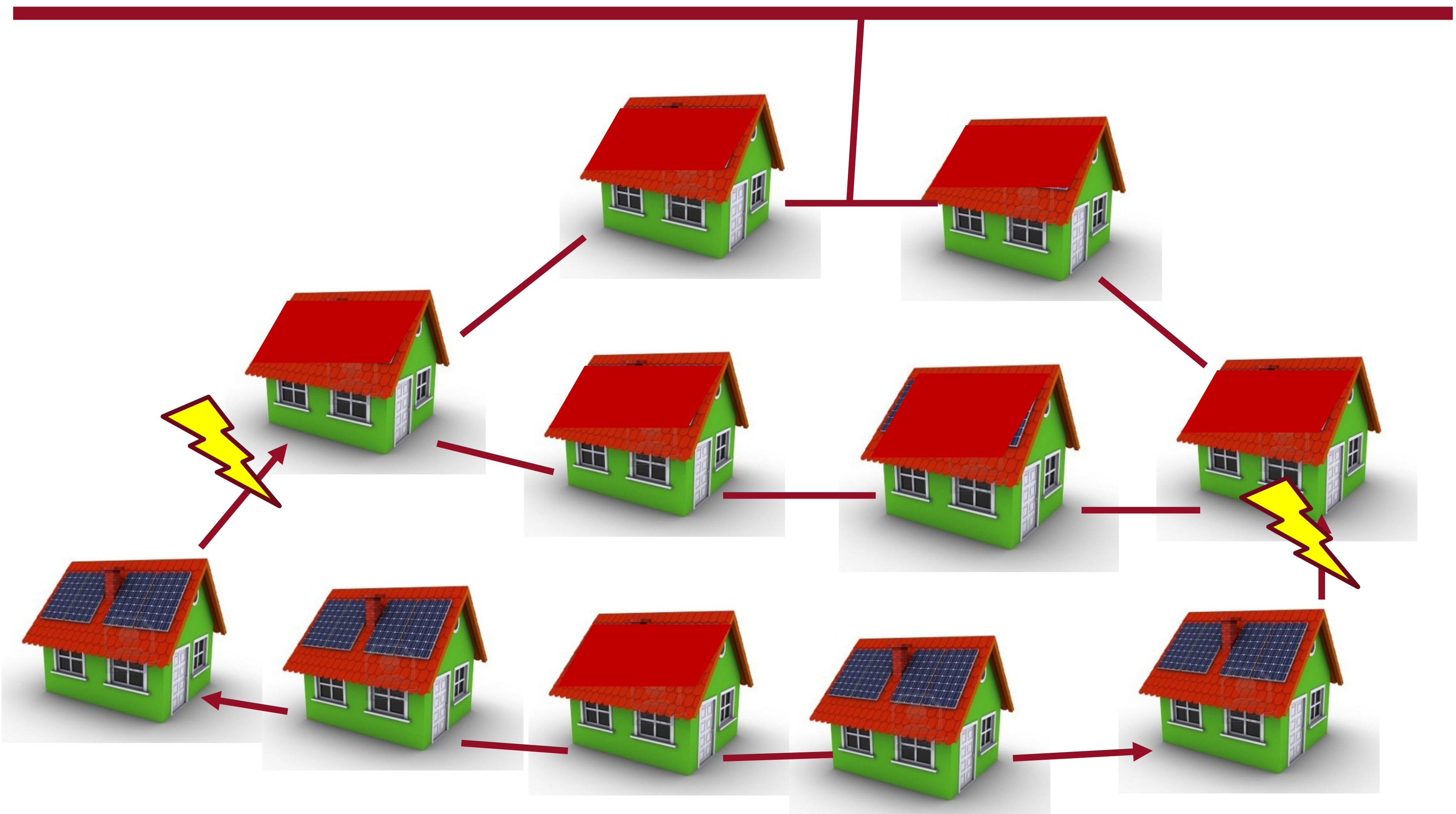


Electricity network:
30% use solar panels

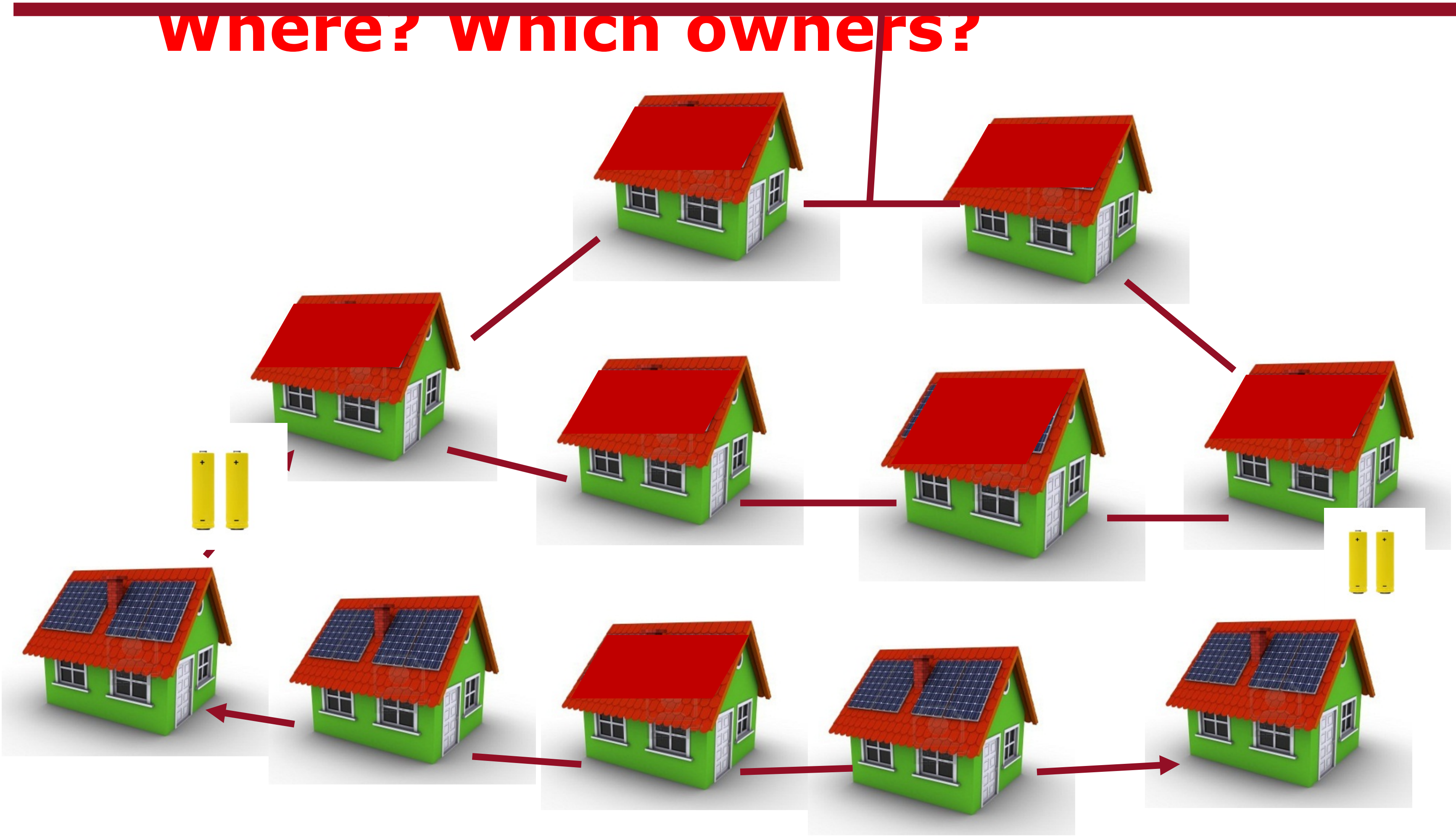


Decision to use solar panels is often based on whether neighbours use solar panels

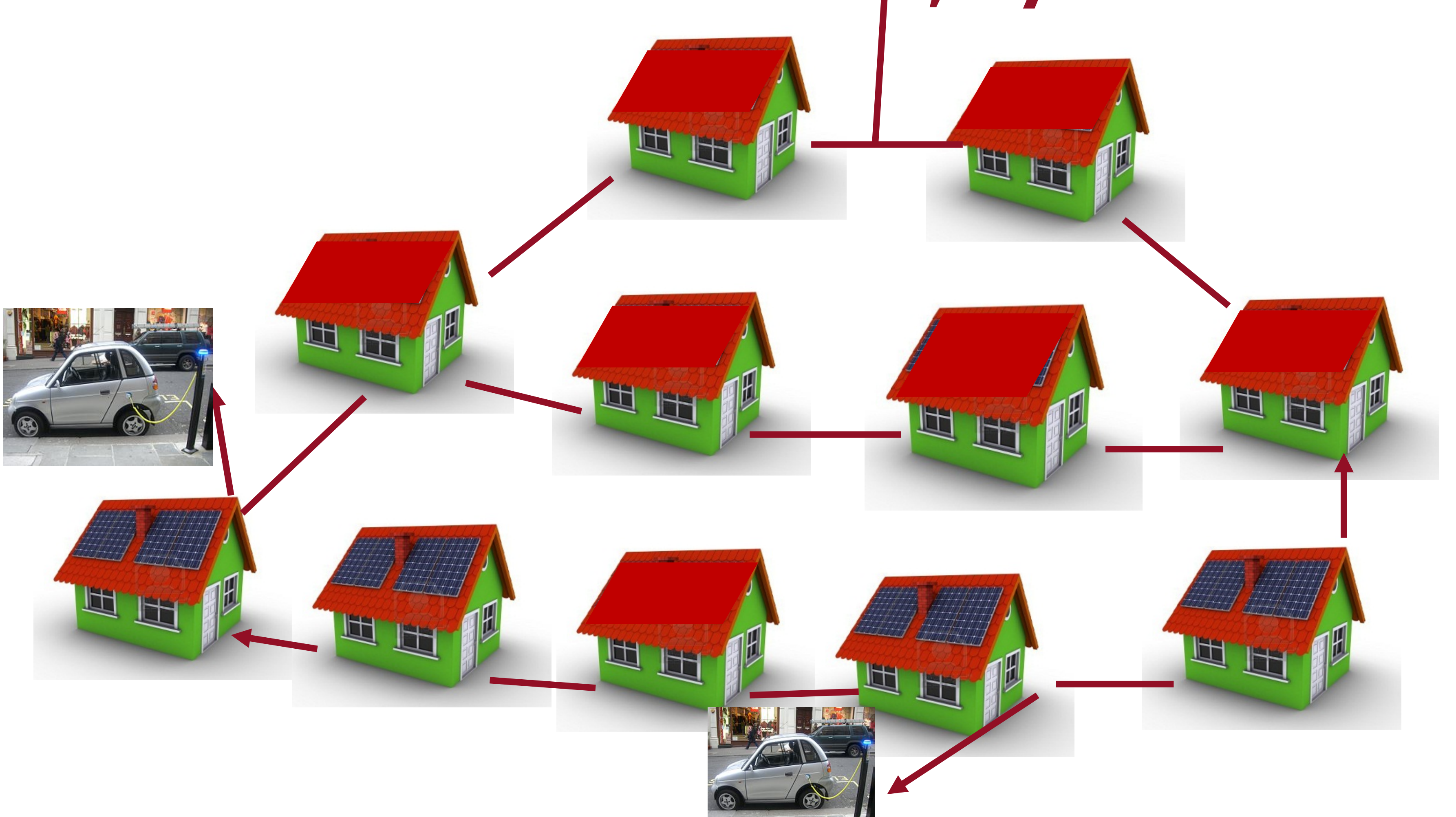
Due to clustering of energy production neighborhood network has not enough capacity to cope



Possible remedy:
Install batteries to store electricity
Question:
Where? Which owners?



Possible remedy:
use energy to charge electric cars?
How many loading points? Where, when can the be used, by whom?

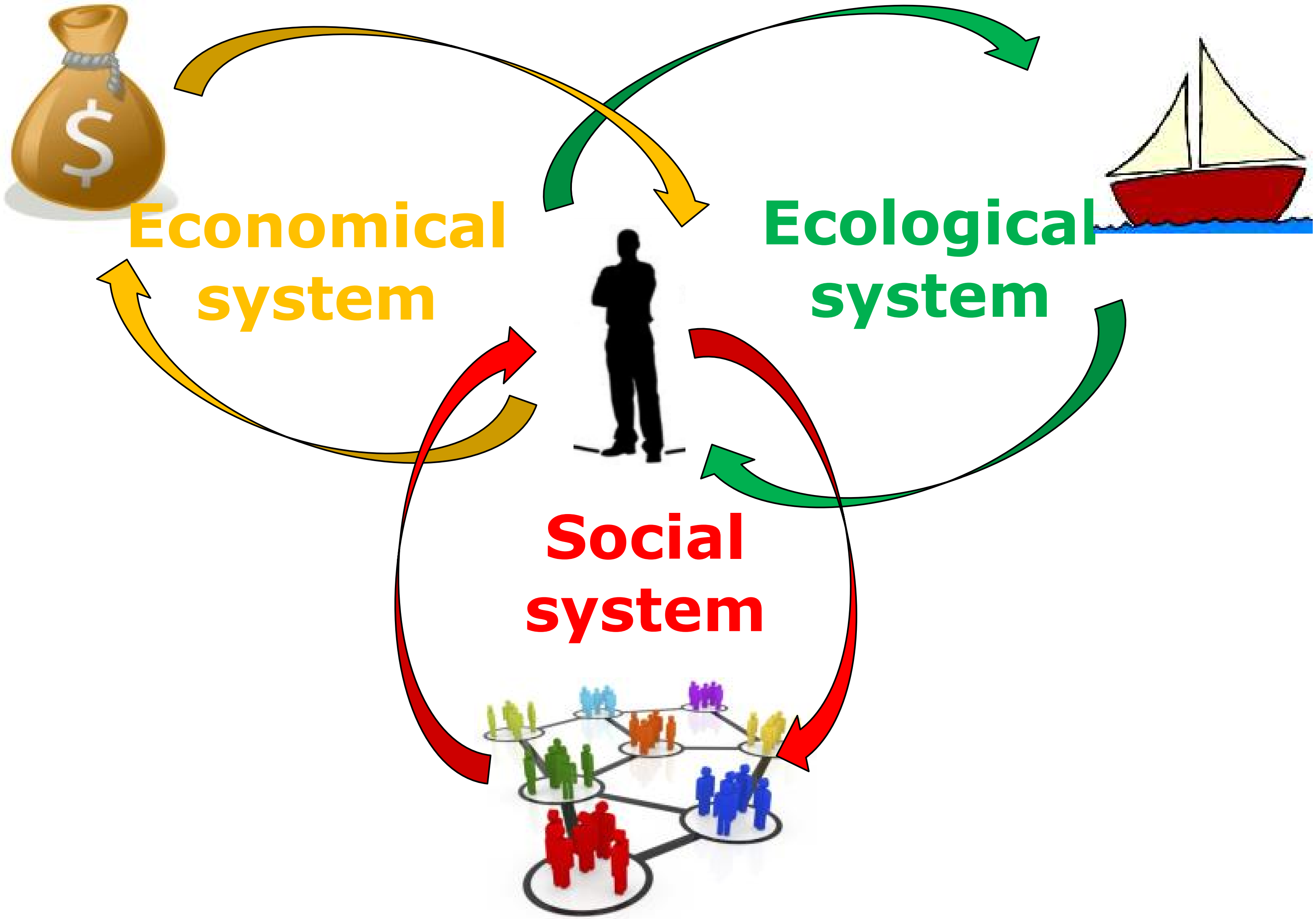


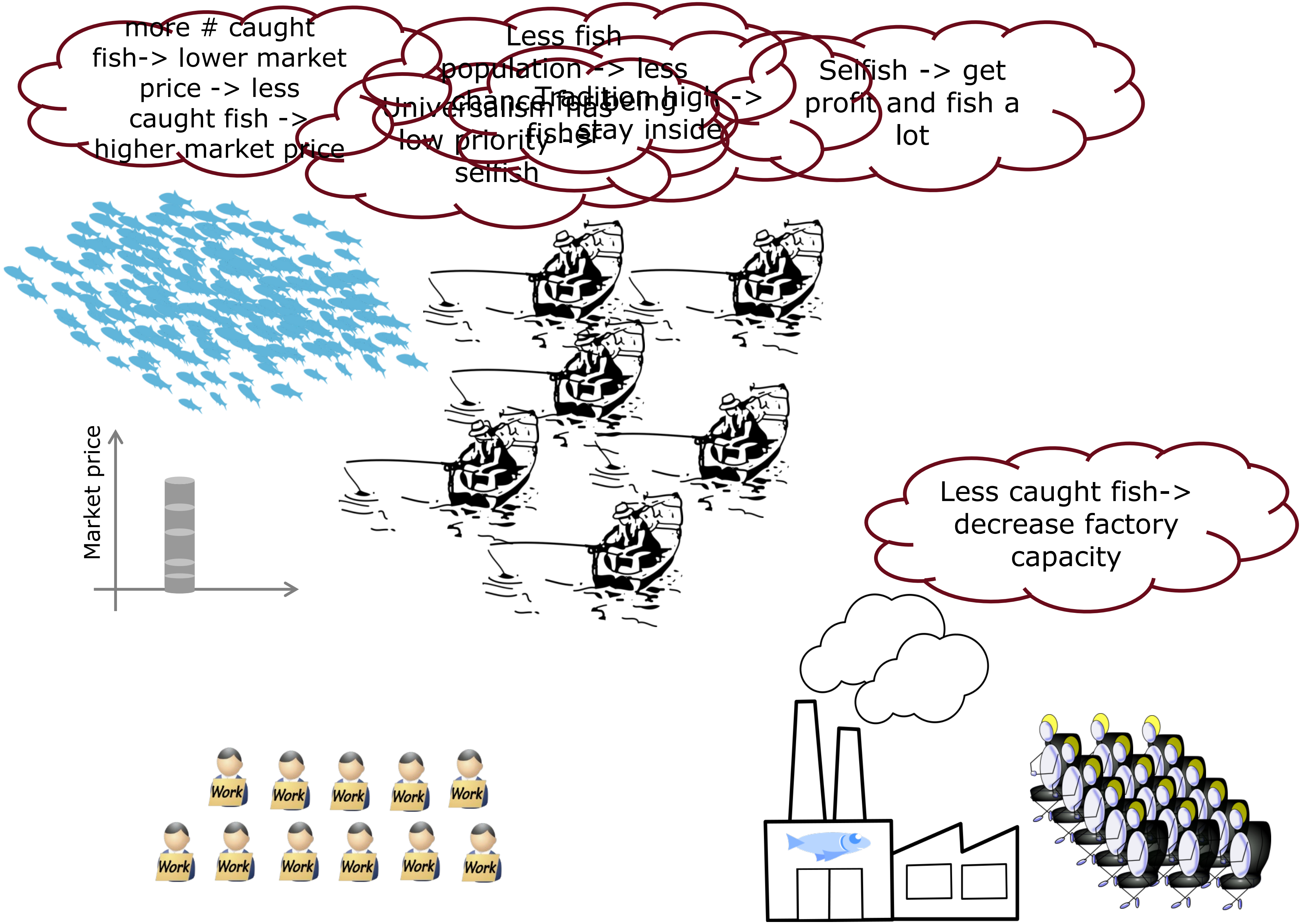
Solutions

- Many more solutions are possible:
  - Increase network capacity
  - Limit energy production
  - …
- How will people react to these changes?
- What are the consequences for the network?

- We need models of people and their decisions in order to answer these questions.

Example 6: Fishery management





more # caught fish-> lower market price -> less caught fish -> higher market price
Less fish population -> less chance for being fished
Universalism has low priority -> selfish
Tradition high -> stay inside
Selfish -> get profit and fish a lot
Market price
Less caught fish-> decrease factory capacity
Work
Work
Work
Work
Work
Work
Work
Work
Work
Work
Work

Combining approaches

- Qualitative and quantitative approaches

- Different types of “models”

Narratives, anecdotal, situated causal rules

vs.

Data, no causal rules

- How to combine these different approaches?

Example: Arabic revolution

- From the text of interviews to causal rules

- Some stay apart from protests by fear of consequences or worry about family
- Some agents are initially motivated by conditions or seeing an attack
- Others may join motivated by positive emotions of (optimism, solidarity…)
- Emotion is most catching when sharing the same physical space
- Emotion builds (and decays) over time
- Knowledge is cumulative
- When protesting people tend to gather in readily identifiable locations

Agent heterogeneity

- Employed/unemployed
- Susceptibility to emotion and their current level of emotional arousal
- Whether on facebook
- What personal friends they have (others they would text/phone)
- Where they are physically
- Current knowledge of attacks, protests happening
- Whether protesting and whether attacked

Different contexts

Different locations:

- Home – away from active involvement, but still in contact via phone and Facebook
- Street – socialising area, vulnerable to attack, face-face emotional influence, start of protests
- Square – where critical mass is achieved, protests persist

Different times of day:

- Waking – calmer at start of day but with variation, clean slate as to knowledge of protests, attacks
- Daytime – unemployed socialise on street, might move to square
- Evening – all socialise in street, might move to square
- Night – employed go home, unemployed might go home

Simulation demo