

An agent-based model to understand the dynamics of domestic energy practices

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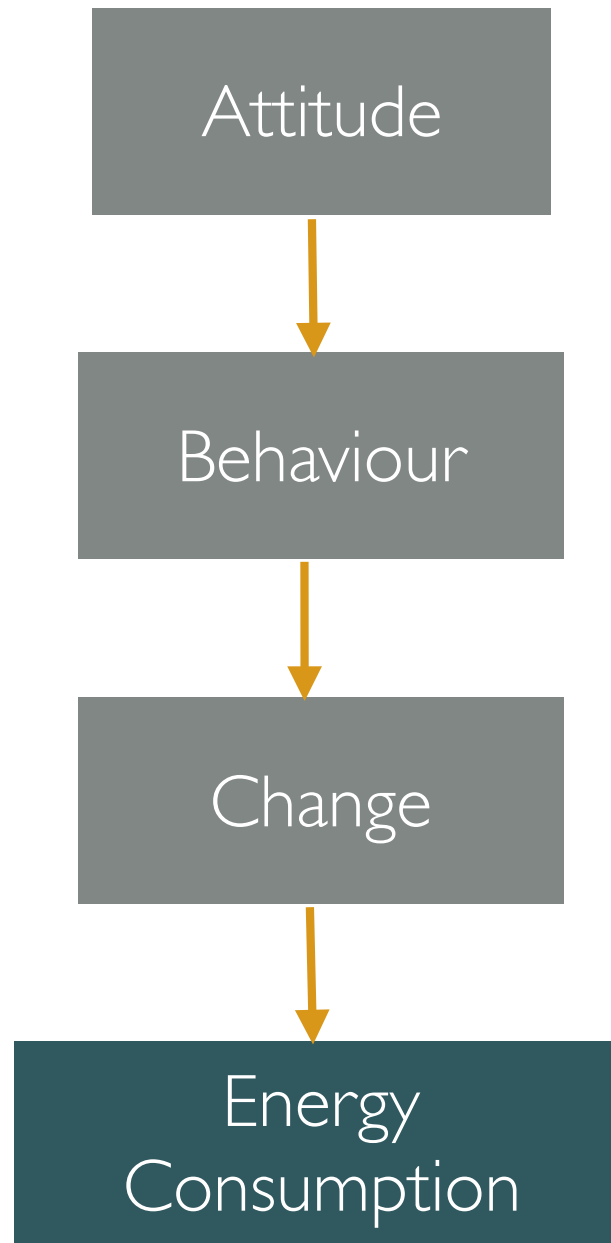
**WholeSEM Annual Conference 2016: Energy Modelling
Insights for Iterative Decision Making**

Outline

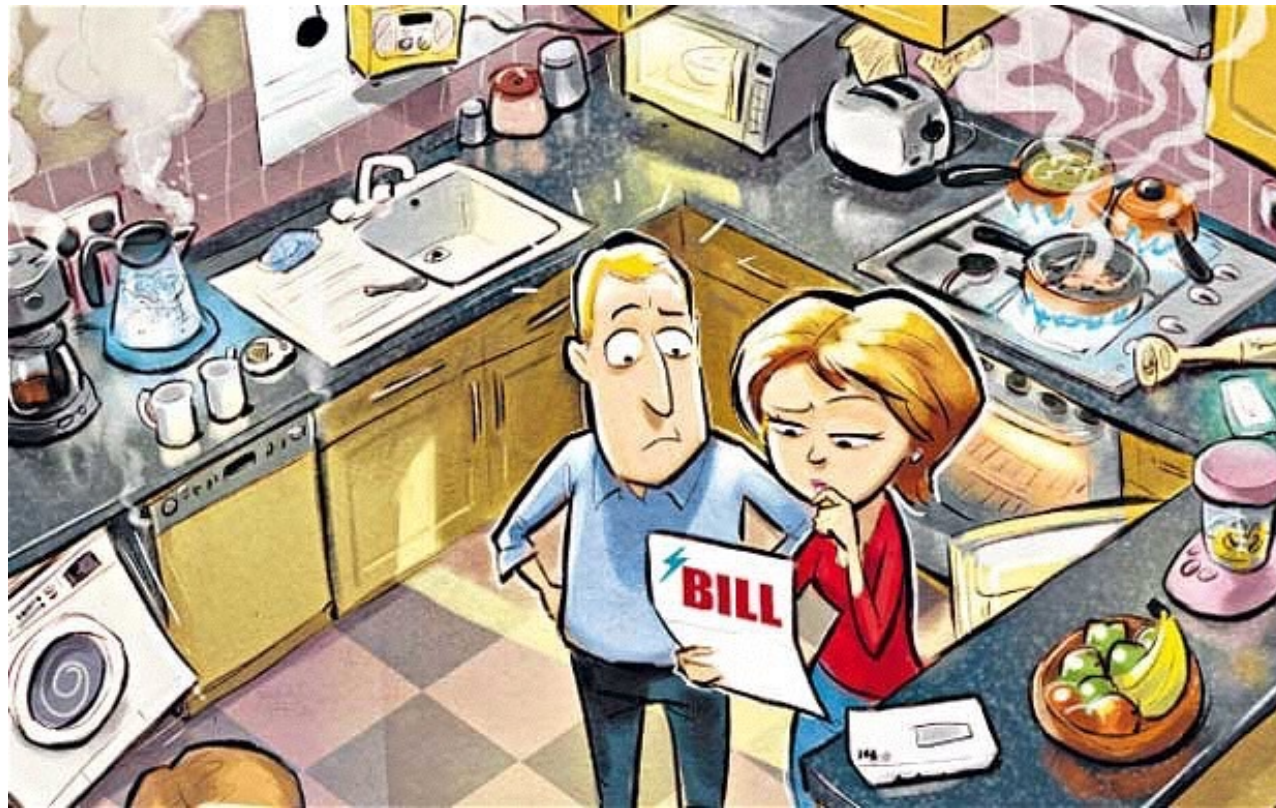
- Motivation
- Social practice theory: concepts covered in our model
- Agent-based modelling: a brief overview
- Our agent based model: Households and Practices in Energy consumption Scenarios (HOPES)
- The HOPES simulation model as a tool to visualise practices and patterns of domestic energy consumption



Background

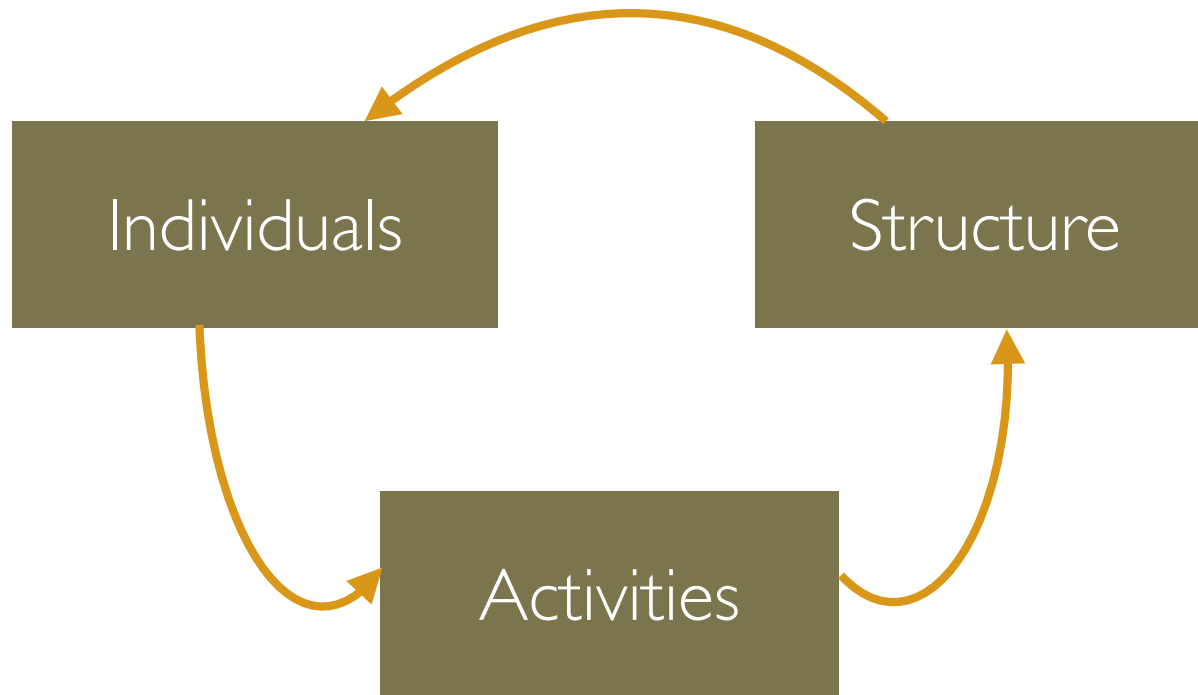


Background

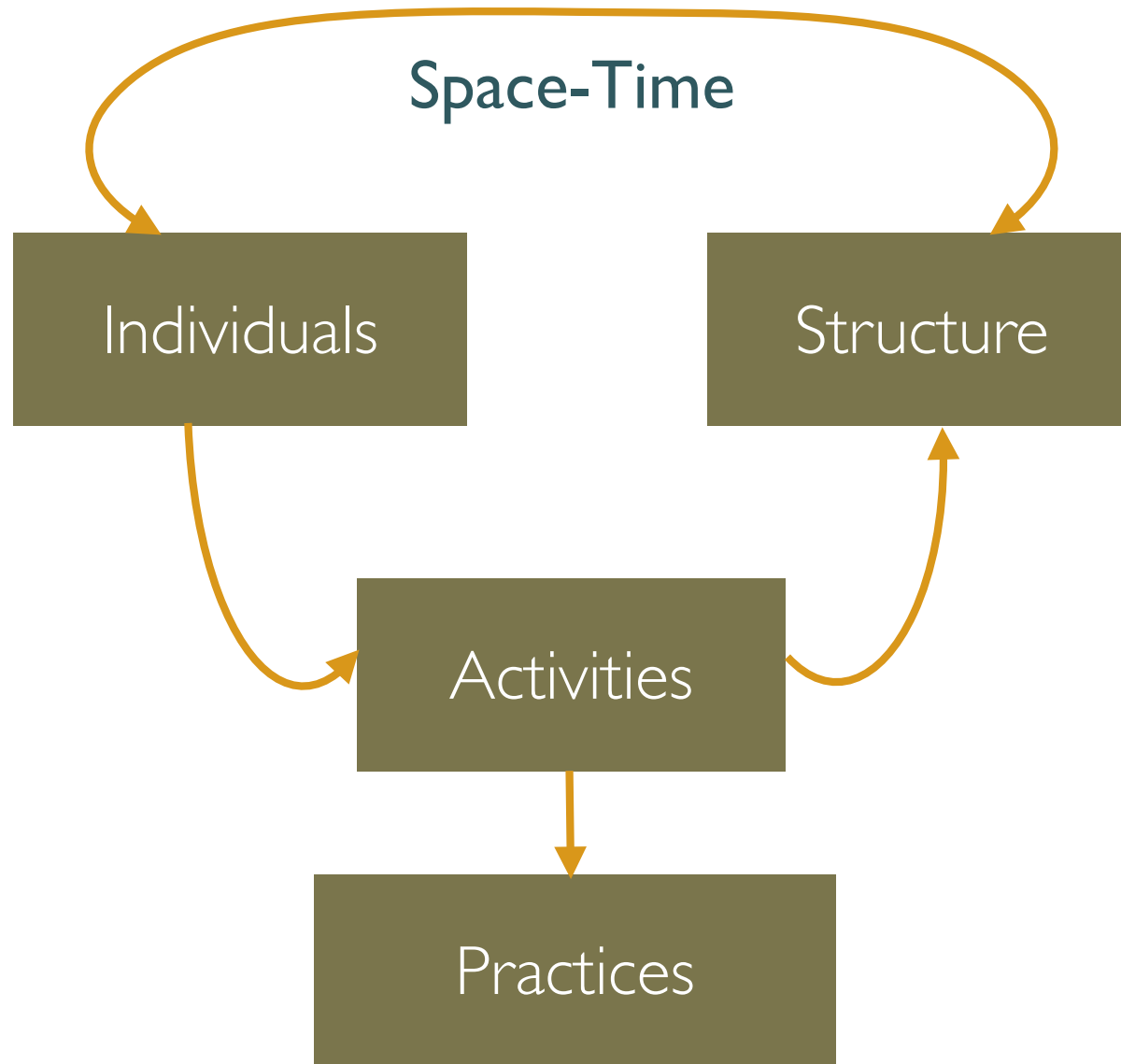


“Need to understand the patterns of household energy consumption by taking into account the **practices** that people perform in **the service of normal everyday life**”

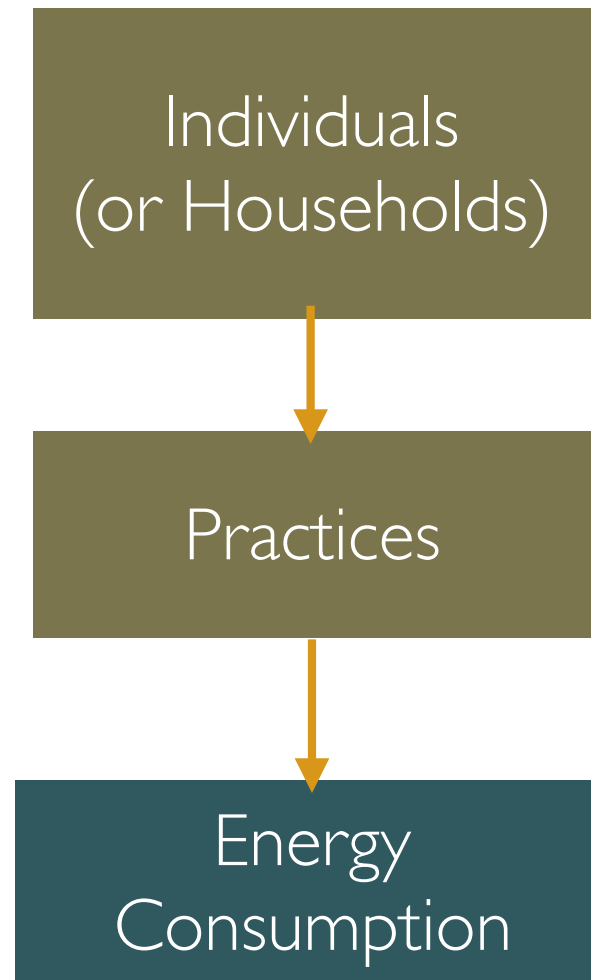
Background: The practice theory view



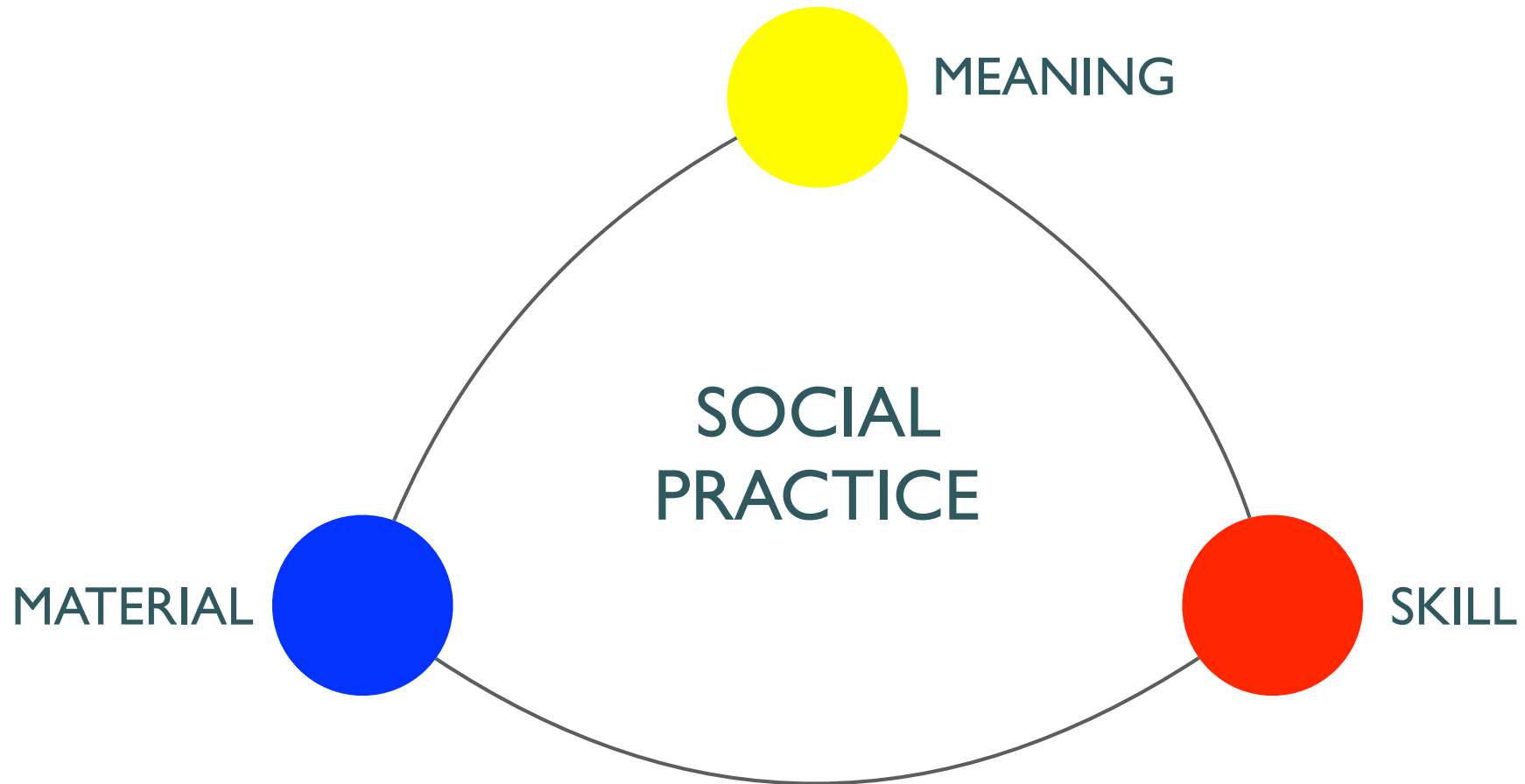
Background: The practice theory view



A practice theory view of energy consumption



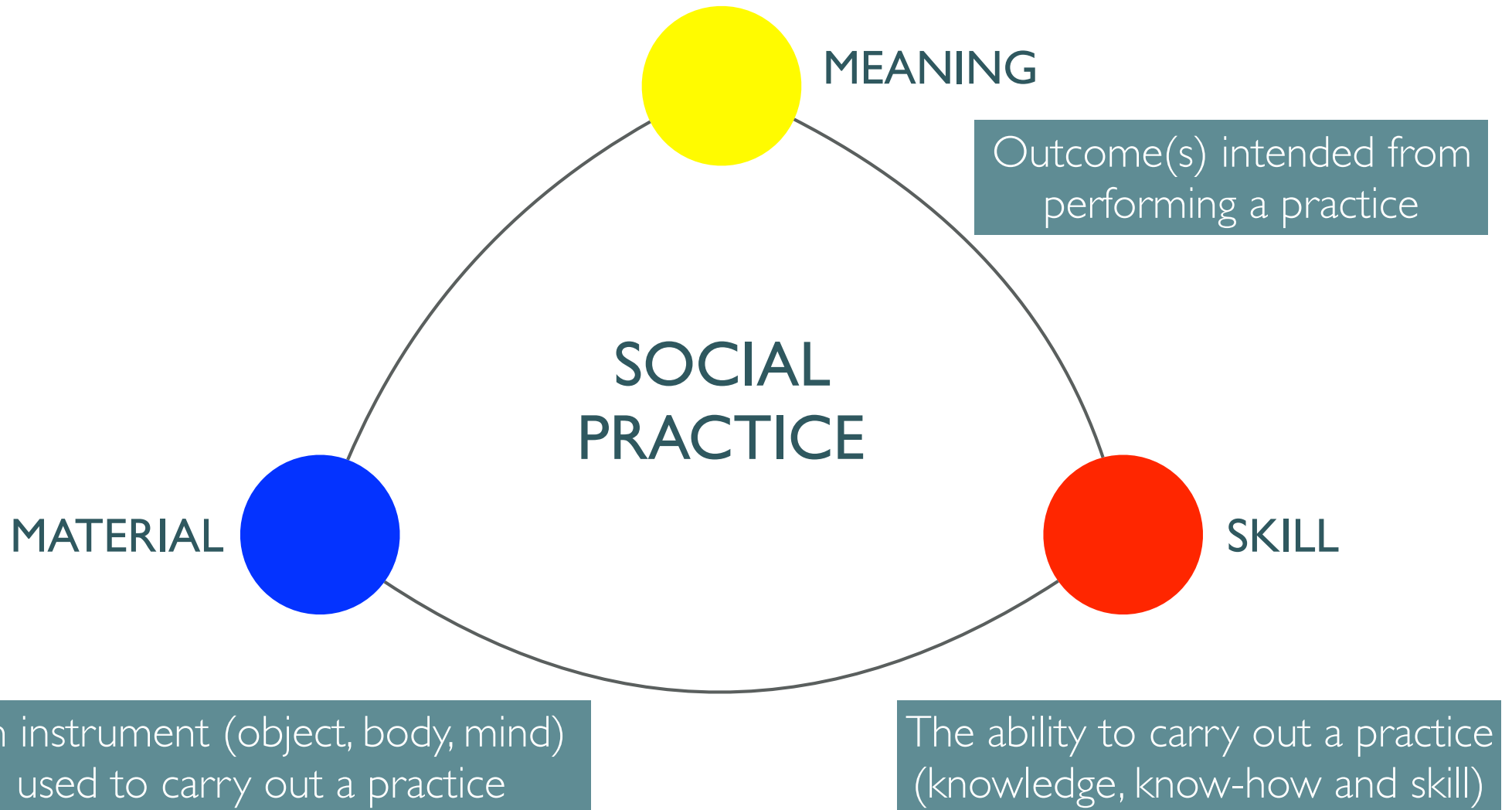
Social Practice Theory: Key Concept I



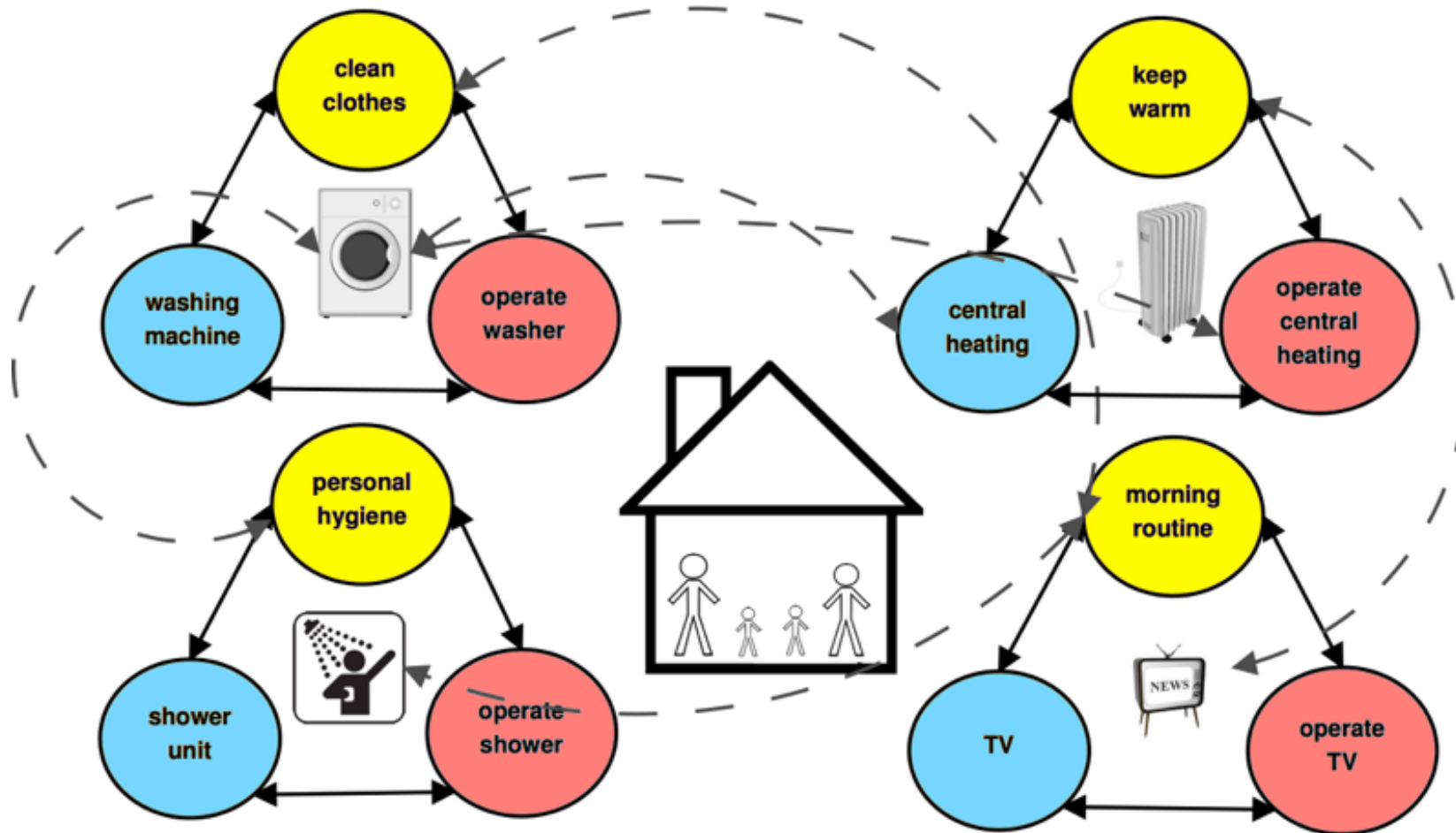
The drawing together of elements (meaning, material, skill) by a practitioner enables the performance of a practice.

— Shove 2012

Social Practice Theory: Key Concept I

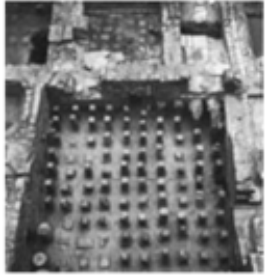


Social Practice Theory: Key Concept 2



Linked performance of practices and sharing of elements between practices

Social Practice Theory: Key Concept 3



Ruin of a hypocaust
underfloor heating system
Source: ACHR News



An ornate cast iron
stove used in 1840s
Source: ACHR News

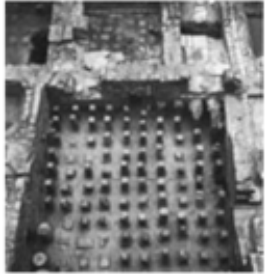


Modern day space
heater



Comfort heating is not just
for people, but for pets,
too

Social Practice Theory: Key Concept 3



Ruin of a hypocaust
underfloor heating system
Source: ACHR News



An ornate cast iron
stove used in 1840s
Source: ACHR News



Modern day space
heater



Comfort heating is not just
for people, but for pets,
too



Elements have changed ~ Practices and the spread of practices have also changed



A House in 1970s or 1980s



A House in 2016

Social Practice Theory: Key Concept 3



PCs in the 90s



PCs in the 2000s



Laptops



Tablets

Social Practice Theory: Key Concept 3



PCs in the 90s



PCs in the 2000s



Laptops



Tablets



Blurring of lines between the ICT and Visual Entertainment practices

Social Practice Theory: Key Concept 3



Ruin of a hypocaust underfloor heating system

Source:ACHR News



An ornate cast iron stove used in 1840s

Source:ACHR News



Modern day space heater



Comfort heating is not just for people, but for pets, too



PCs in the 90s



PCs in the 2000s



Laptops



Tablets

Not only have appliances changed over the years, but the ways in which appliances are used have also changed over the years. This in turn influences energy use.

A model of energy consumption based on social practice theory



A model where the drawing together of meaning, material and skill elements enables the performance of practices

A model of energy consumption based on social practice theory



A model where the drawing together of meaning, material and skill elements enables the performance of practices



Performance of practices influences energy consumption

A model of energy consumption based on social practice theory



A model where the drawing together of meaning, material and skill elements enables the performance of practices



Performance of practices influences energy consumption



Changes in elements affects practices, and subsequently, energy consumption

A model of energy consumption based on social practice theory



A model where the drawing together of meaning, material and skill elements enables the performance of practices



Performance of practices influences energy consumption



Changes in elements affects practices, and subsequently, energy consumption



Performance of practices may be linked

Our approach

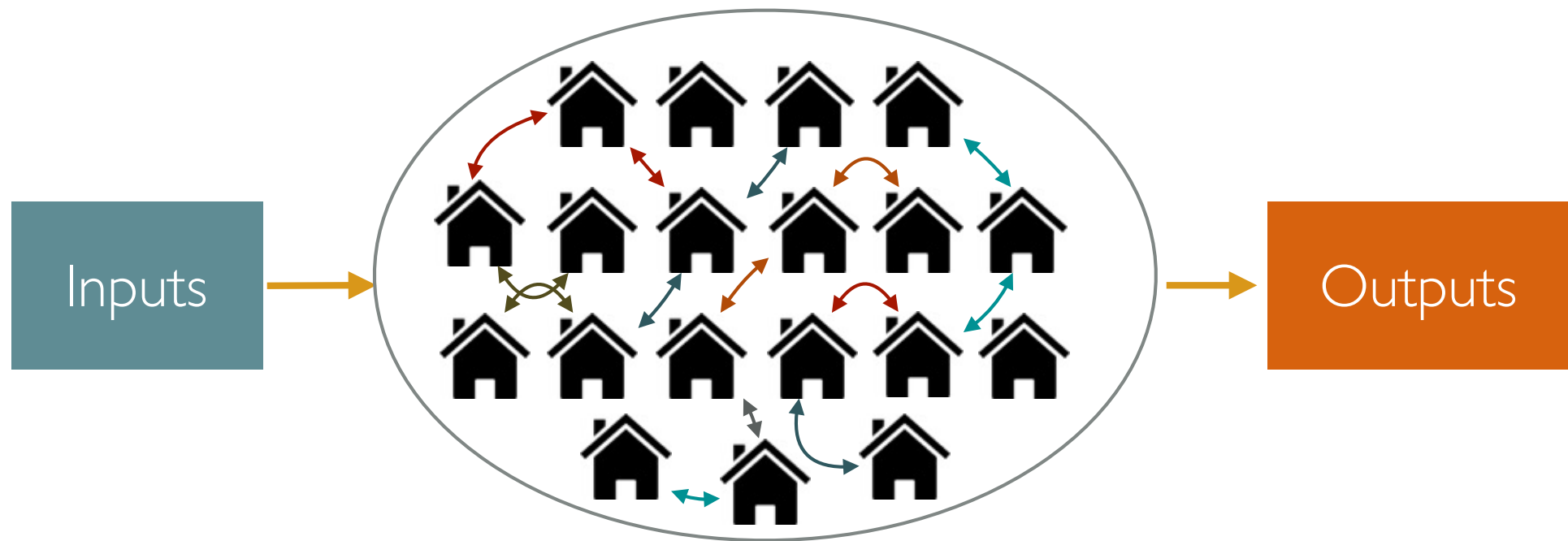
Agent-based modelling

An approach used to situate an initial population of agents (autonomous and heterogenous entities) in a relevant environment; allow them to interact according to simple rules, and thereby generate (or 'grow') a macroscopic phenomenon from bottom-up. (Epstein 1999:42)

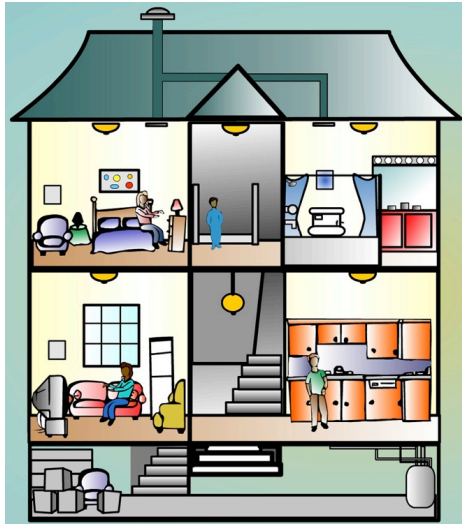
Our approach

Agent-based modelling

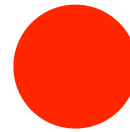
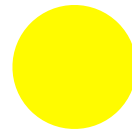
An approach used to situate an initial population of **agents** (autonomous and heterogenous entities) in a relevant **environment**; allow them to **interact** according to **simple rules**, and thereby **generate (or 'grow') a macroscopic phenomenon from bottom-up**. (Epstein 1999:42)



The agents in the model



Households

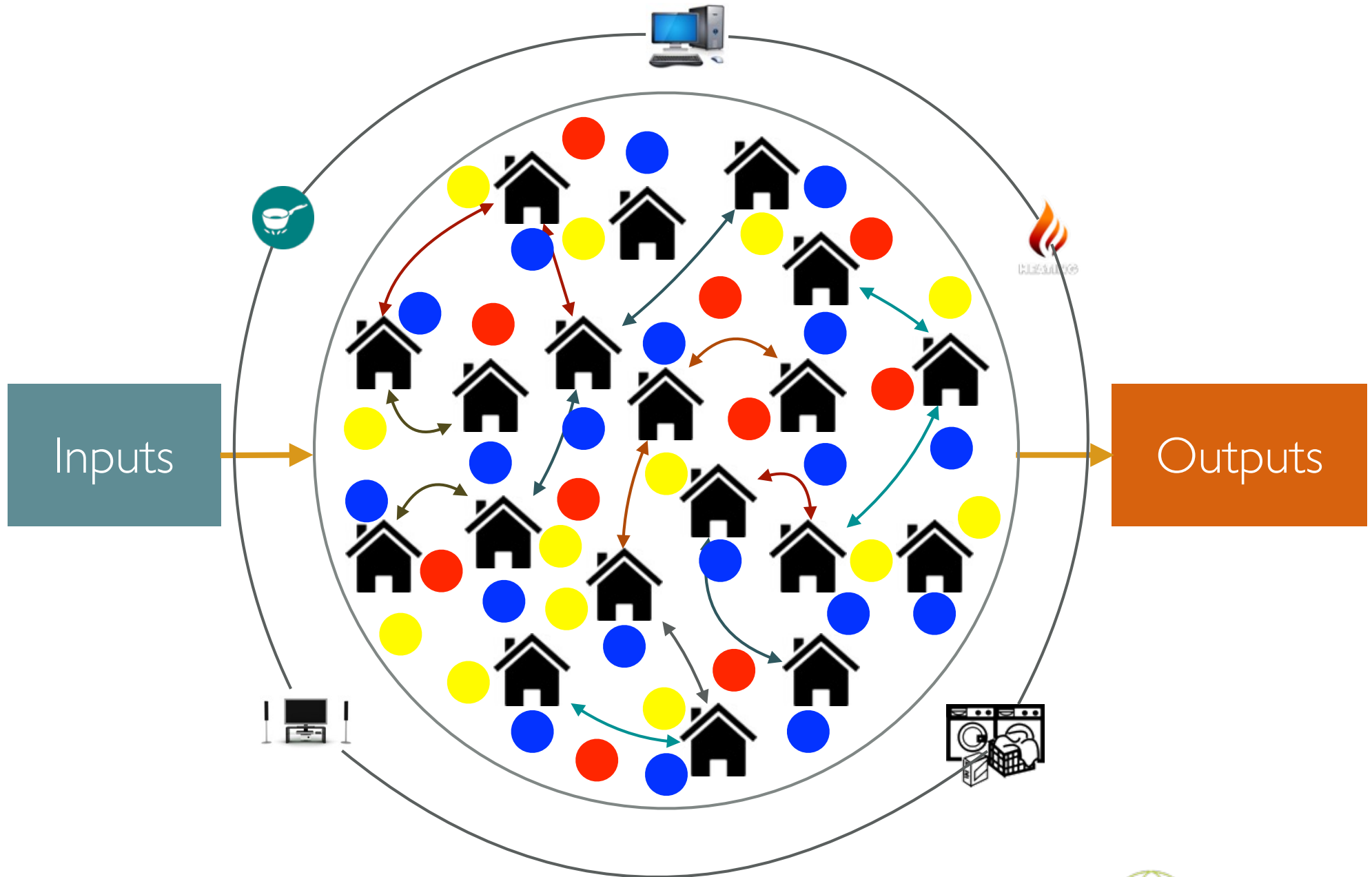


Elements

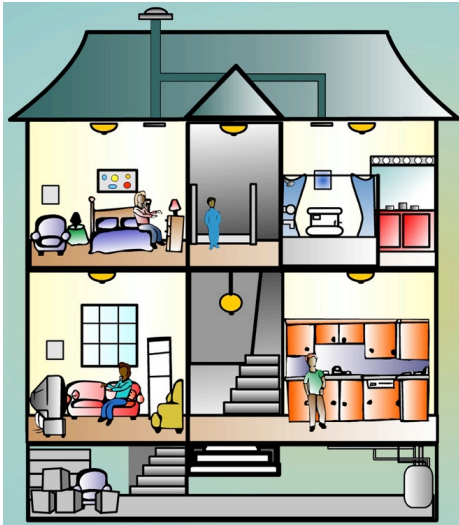


Practices

Our model World



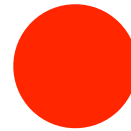
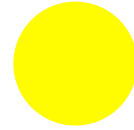
The inputs to the model



Households

Input

Type
Tenure
Composition
Occupancy
Rooms
etc.



Elements

Input

Type
Practice
Material - needs energy?



Practices

Input

Category

The outputs we are interested in

Patterns of practices

Visualise the daily performance of practices

The outputs we are interested in

Patterns of practices

Visualise the daily performance of practices

Patterns of elements

Visualise how the elements of practices change over time

The outputs we are interested in

Patterns of practices

Visualise the daily performance of practices

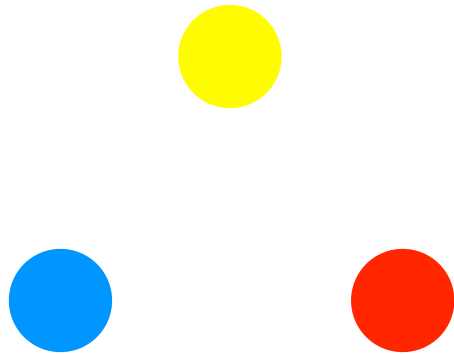
Patterns of elements

Visualise how the elements of practices change over time

Patterns of household energy consumption

Visualise how the performance of practices leads to energy consumption

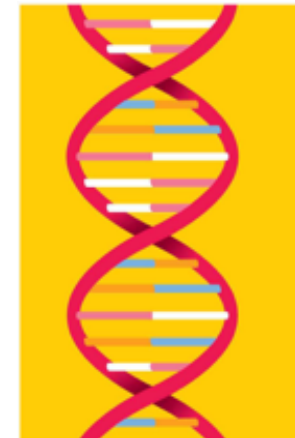
The rules for interaction



Rules that allow households to pick elements

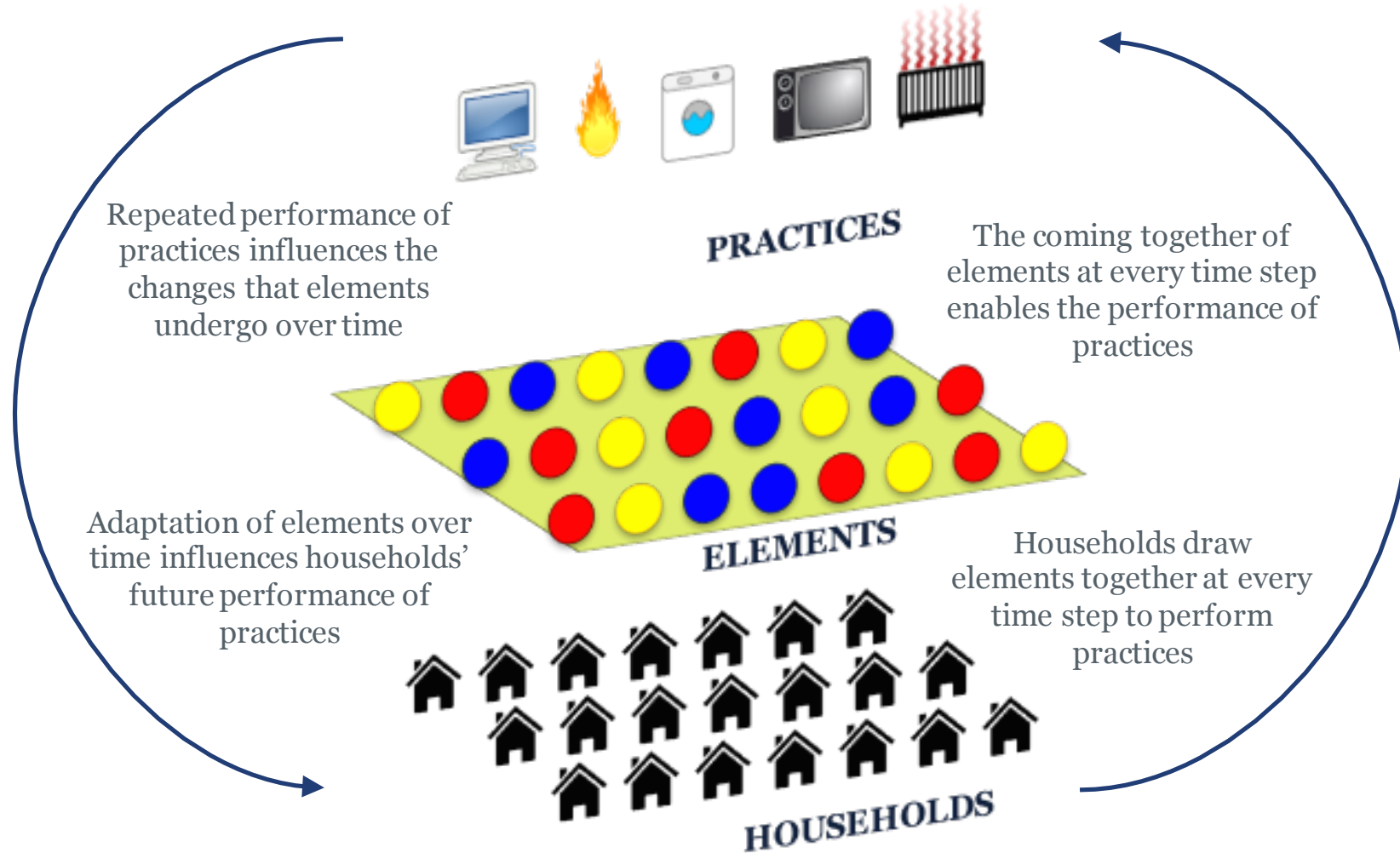


Rules that allow the linking of appropriate elements to perform practices

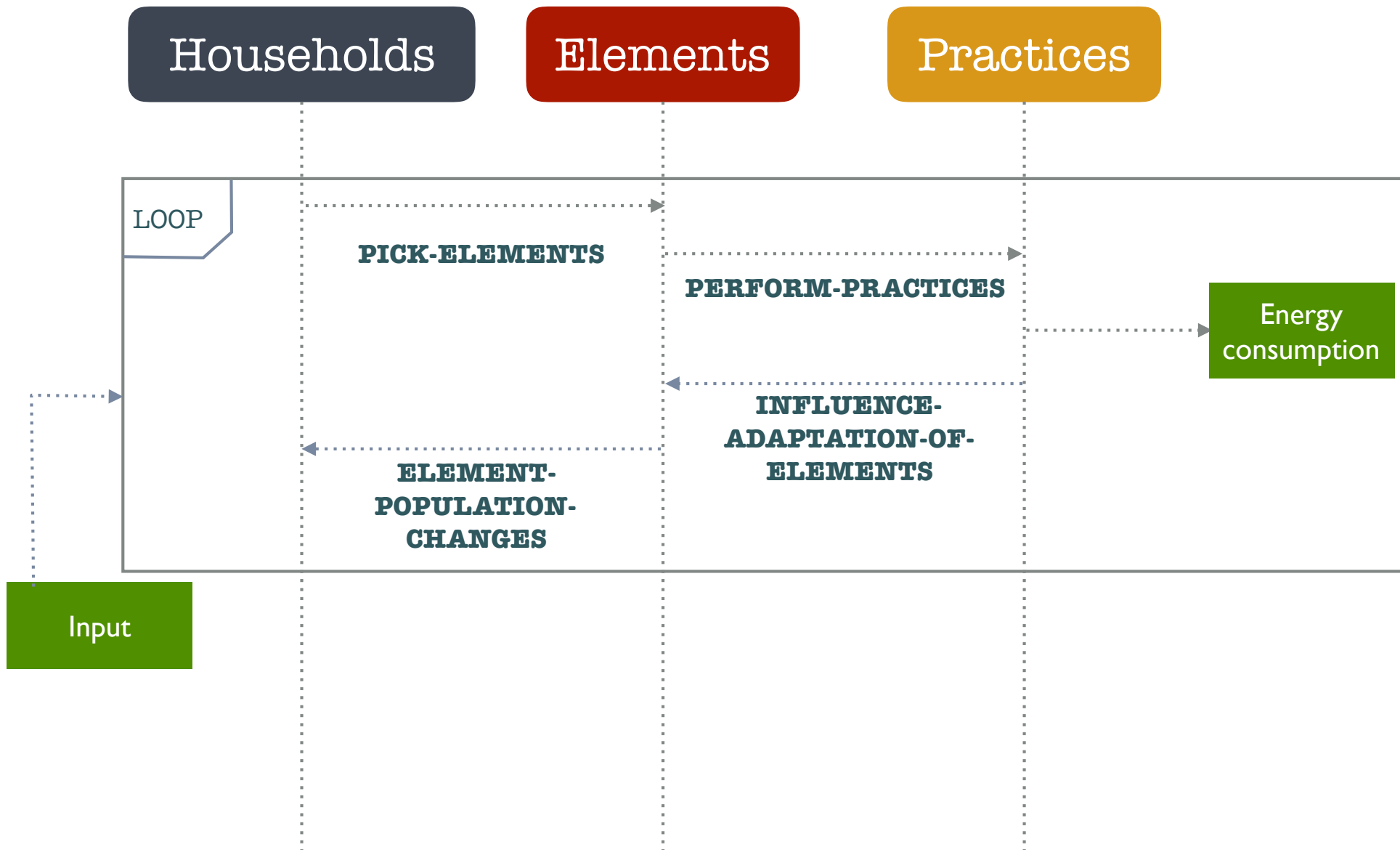


Rules that allow the adaptation of elements

Bringing it all together



The sequential order of processes linking the agents



The 'Pick-elements' process

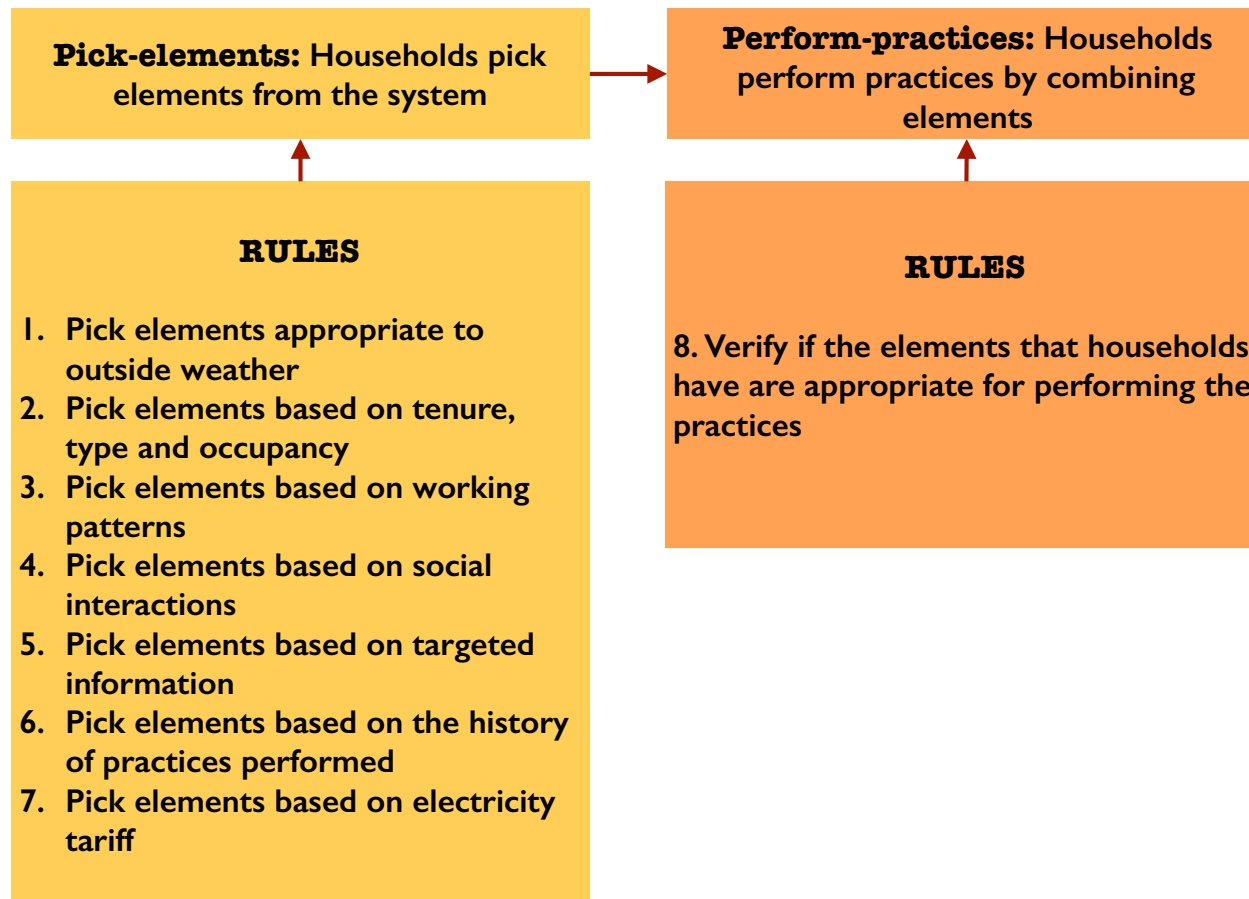
Pick-elements: Households pick elements from the system



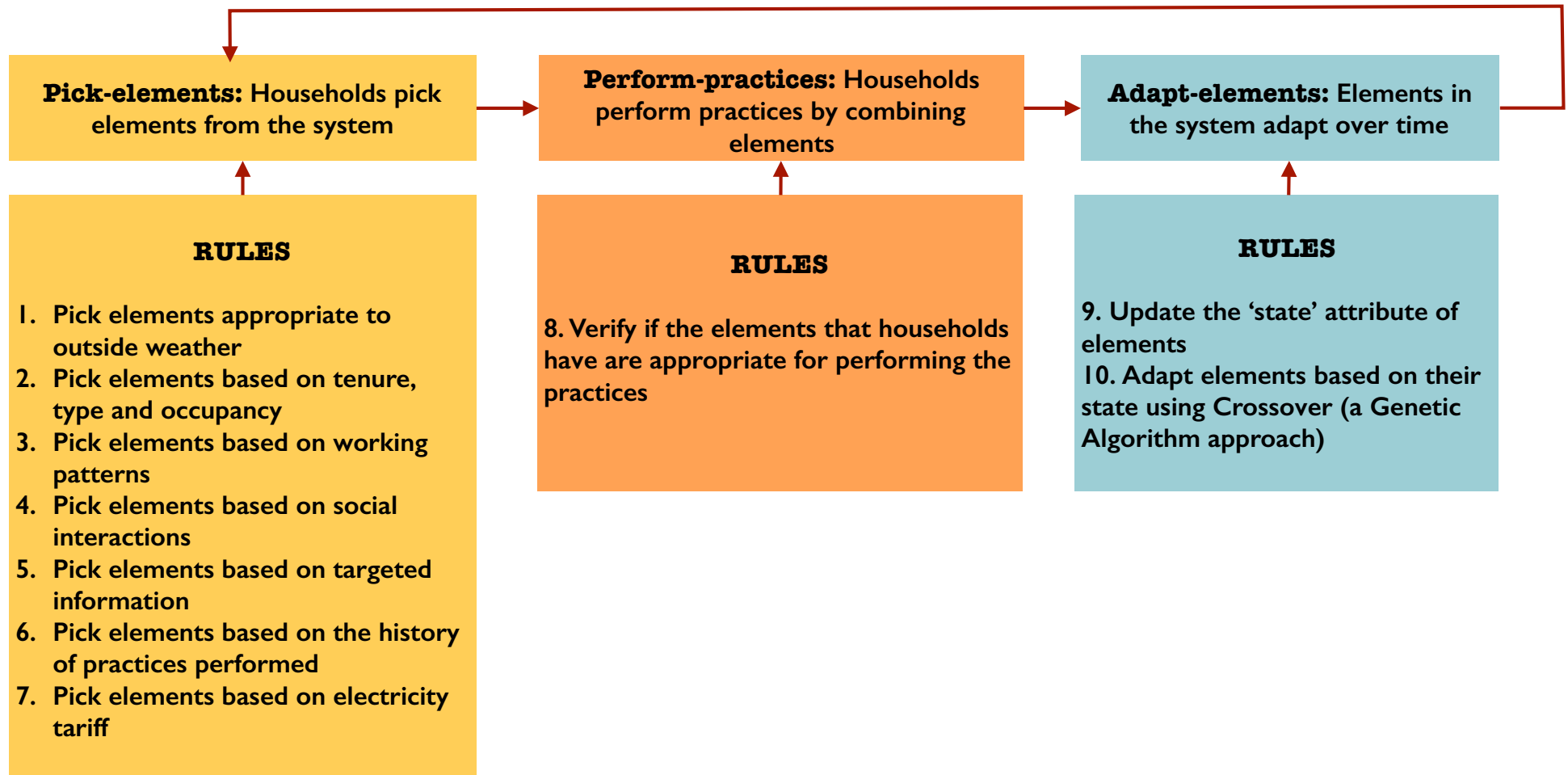
RULES

1. Pick elements appropriate to outside weather
2. Pick elements based on tenure, type and occupancy
3. Pick elements based on working patterns
4. Pick elements based on social interactions
5. Pick elements based on targeted information
6. Pick elements based on the history of practices performed
7. Pick elements based on electricity tariff

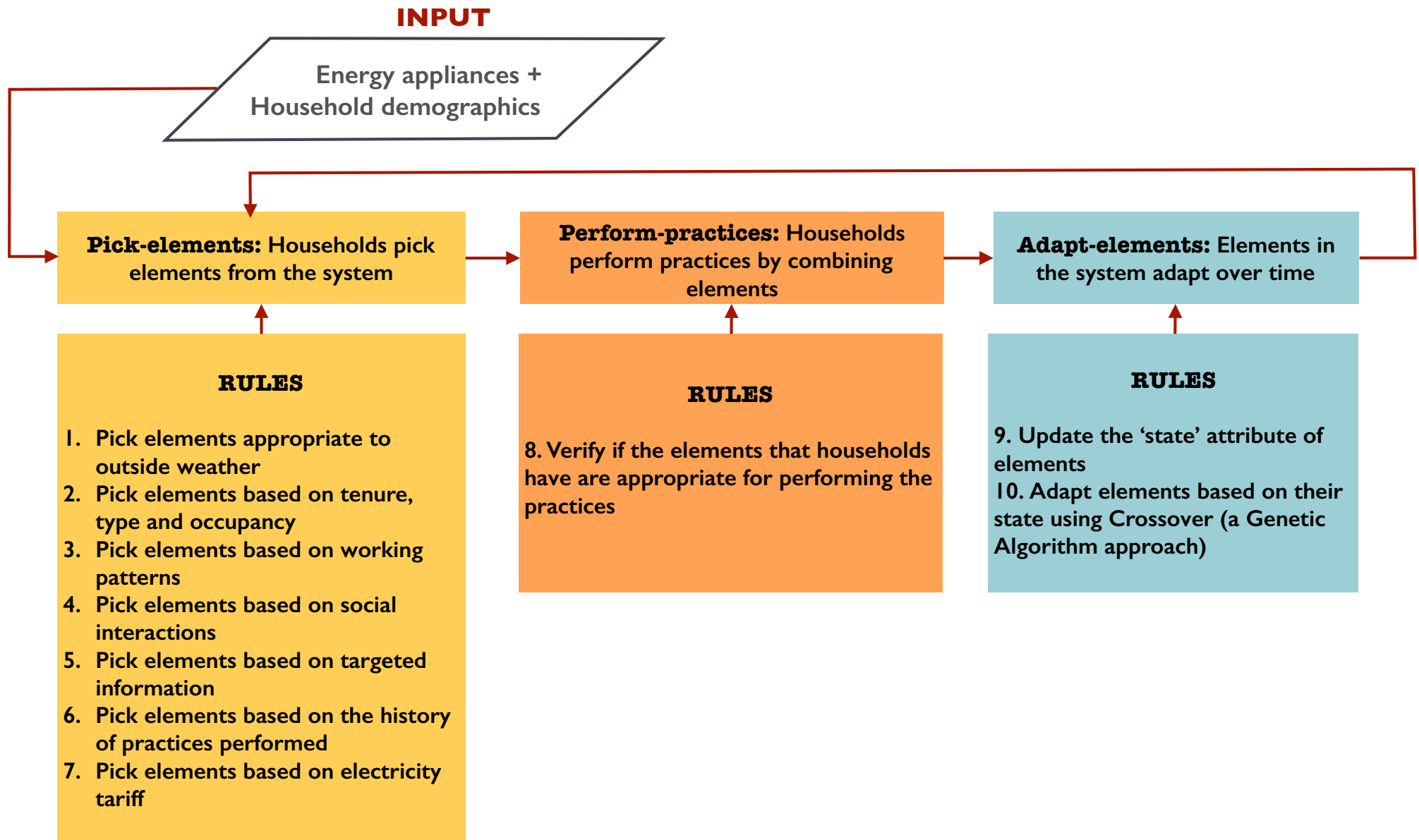
The 'Perform-practices' process



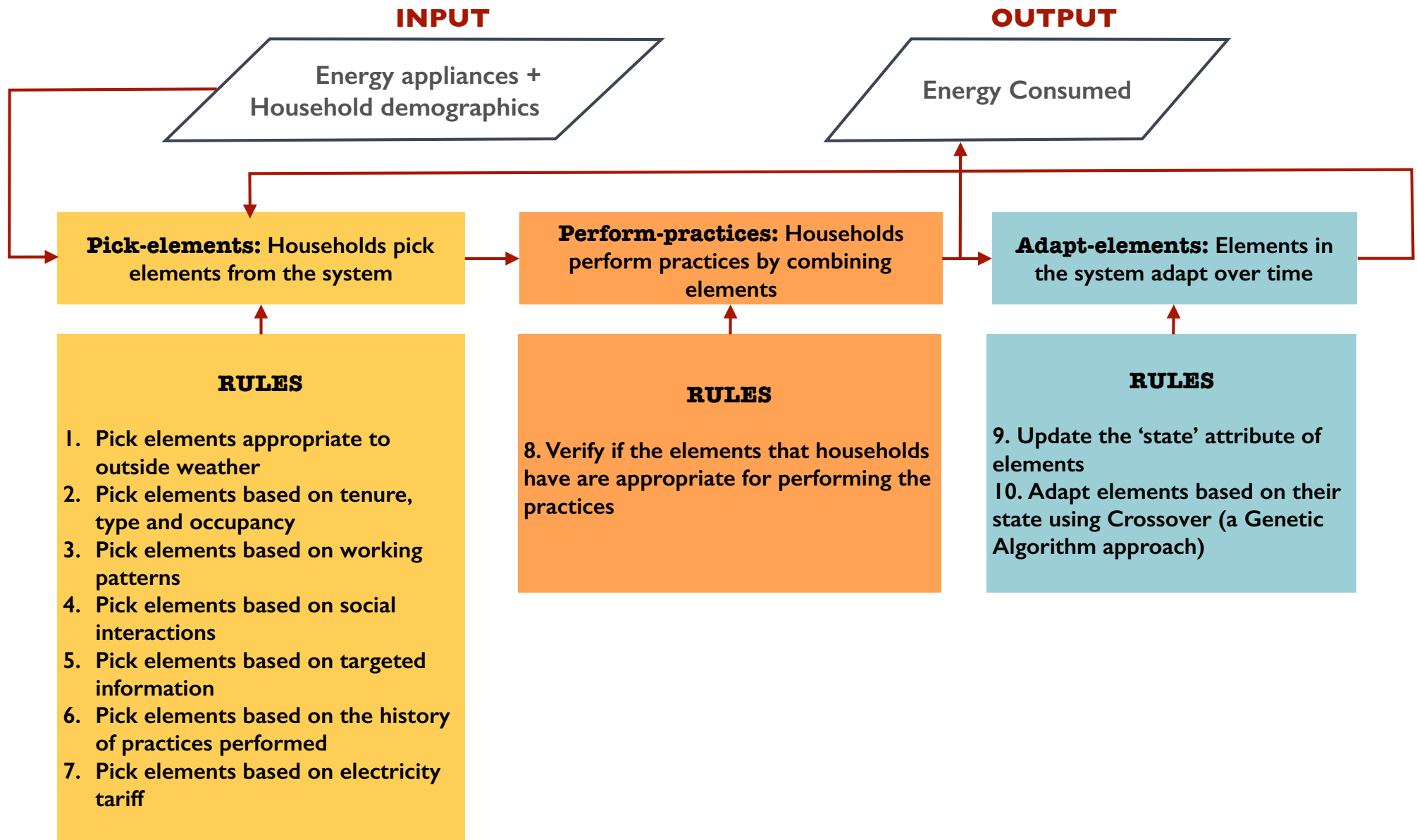
The 'Adapt-elements' process



Inputs to the HOPES model



The HOPES model



HOPES simulation: An overview

Factors influencing the process PICK ELEMENTS

On TARGETEDINFO?
 Off

On SOCIAL?
 Off

On PRICING?
 Off

On HABIT?
 Off

On DEMOGRAPHICS?
 Off

Pricing Scenario

Pricing
ToU ▼

Factors influencing the process ADAPT ELEMENTS

COEVOLUTION 0.0

EVOLUTION 0.0

Similar-meaning 0.0

Similar-material 0.0

Similar-skill 0.0

ADAPT-MEANING 0

ADAPT-MATERIAL 0.0

ADAPT-SKILL 0.0

HOPES simulation: An overview

Factors influencing the process PICK ELEMENTS

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Factors influencing the process ADAPT ELEMENTS

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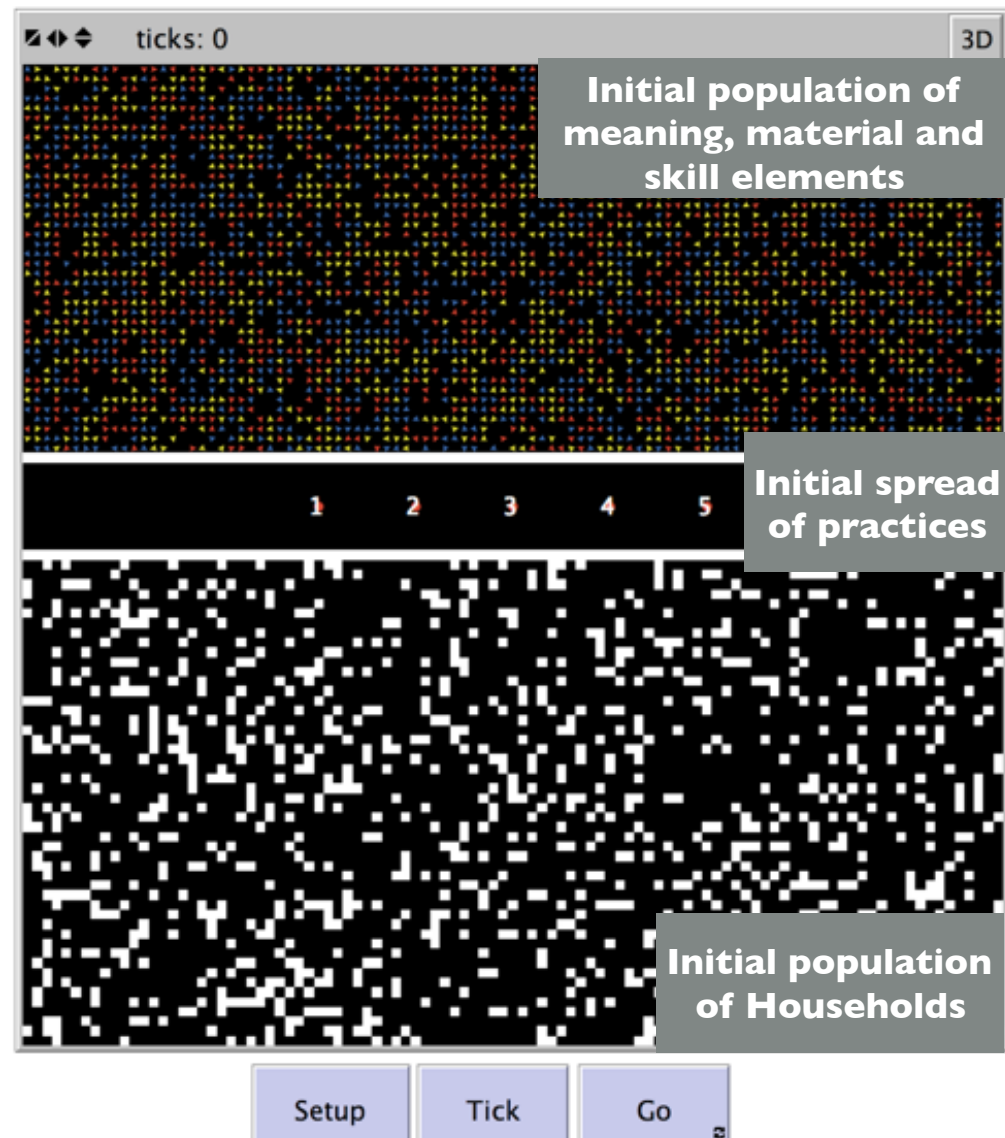
Similar-material 0.0

Similar-skill 0.0

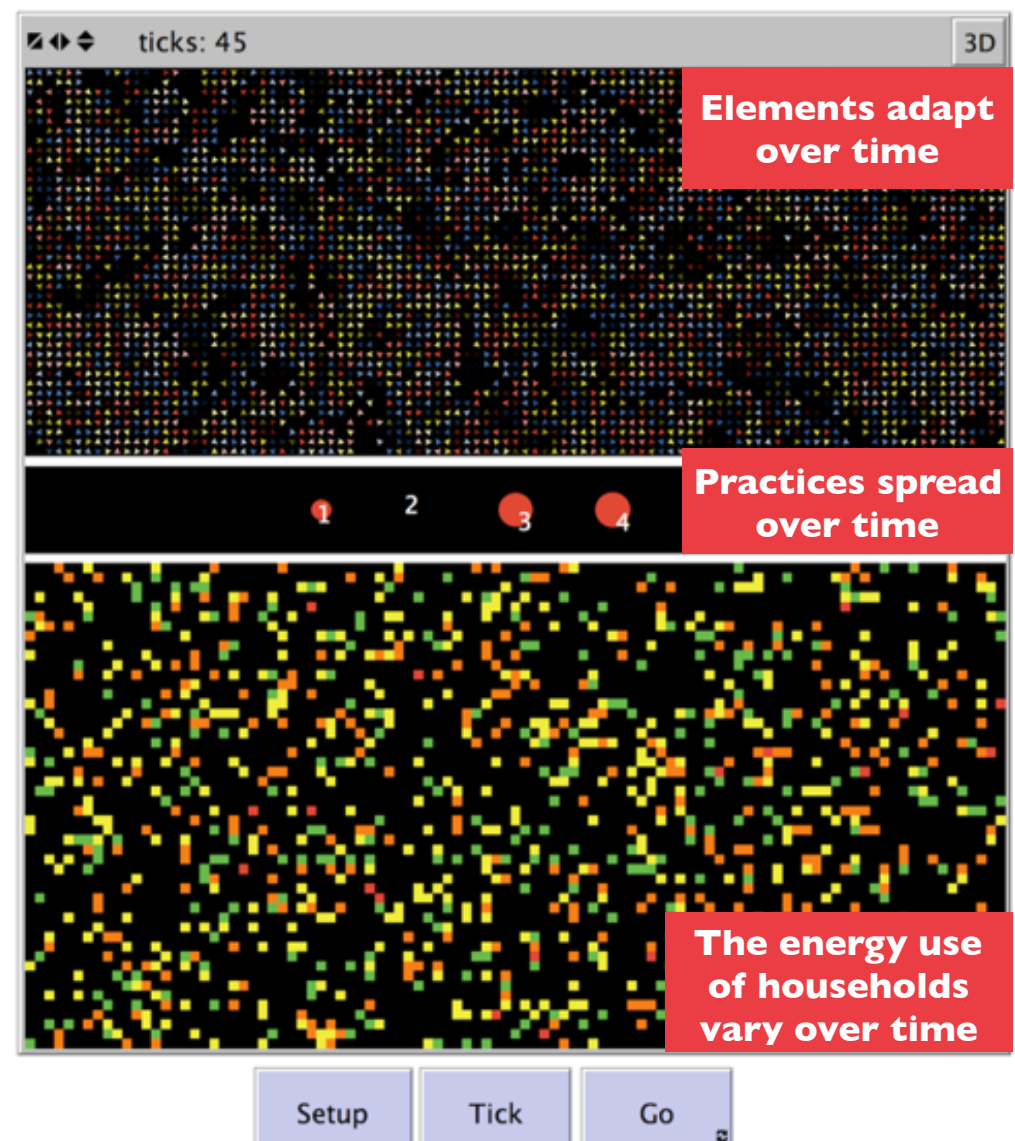
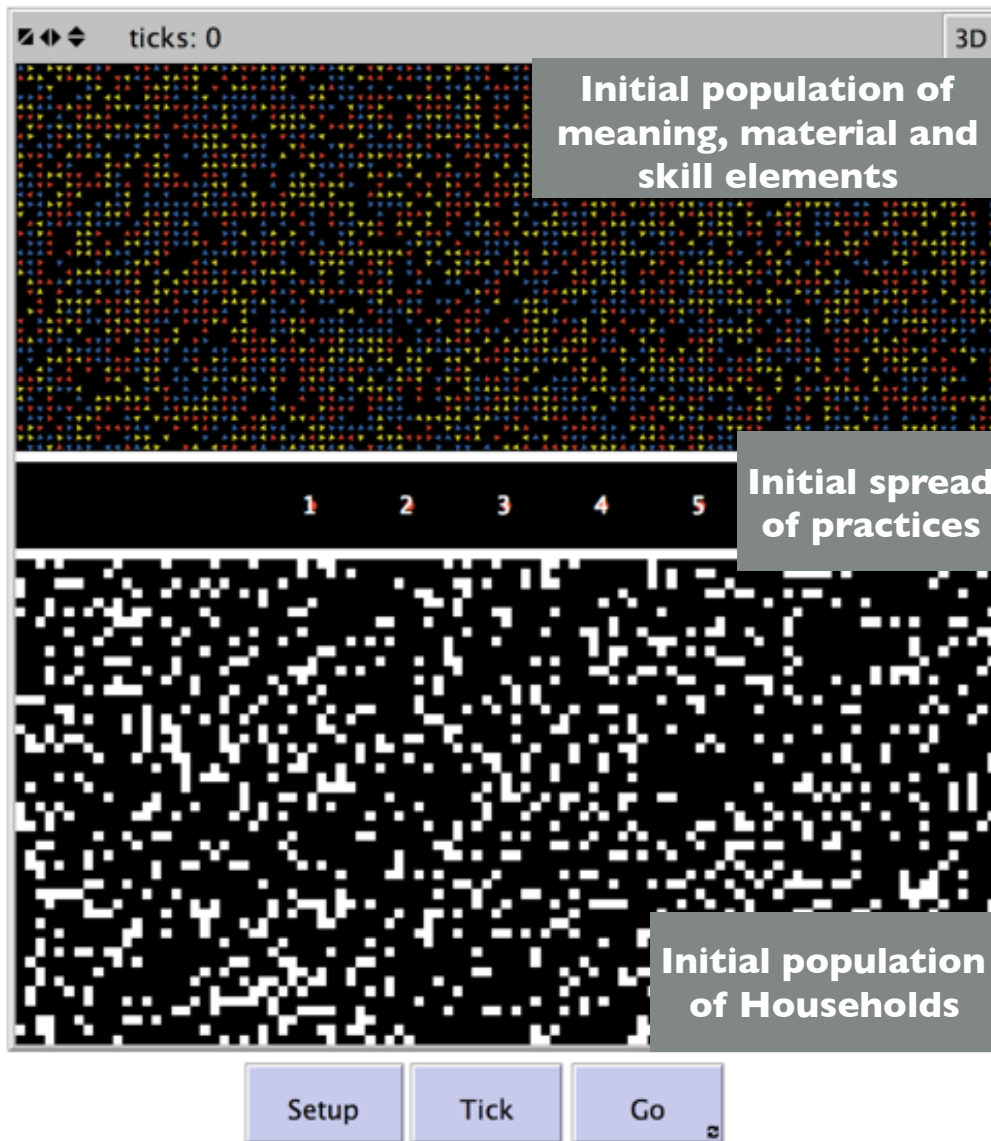
ADAPT-MEANING 0

ADAPT-MATERIAL 0.0

ADAPT-SKILL 0.0



HOPES simulation: An overview



HOPES: Next Steps

I HOPES Calibration

Initialise household population

wholeSEM
Surrey
Household
survey

Low carbon
London survey

HOPES: Next Steps

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Initialise household population

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London survey

Perform practices

wholeSEM
Surrey Walking
interviews

Practice theory
literature

HOPES: Next Steps

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Monitoring study

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Adapt elements

Random 'model
assumptions'

HOPES: Next Steps

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Adapt elements

Random 'model
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2 HOPES Validation

Validate HOPES using relevant datasets

HOPES: Next Steps

I HOPES Calibration

Initialise household population

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Adapt elements

Random 'model
assumptions'

2 HOPES Validation

Validate HOPES using relevant datasets

3 Scenarios for HOPES: our current plan

- (a) Pricing: Run the HOPES model under different pricing scenarios.
- (b) Adoption of appliances: Run the HOPES model using 'different types of material' elements

Thank You

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The UK Engineering and Physical Sciences Research Council (EPSRC) supported this work through the Whole Systems Energy Modelling Consortium (WholeSEM) project (grant EP/K039326/1)