

# Sharing Economy in Future Peer-to-peer Electricity Trading Markets: Security and Privacy Analysis

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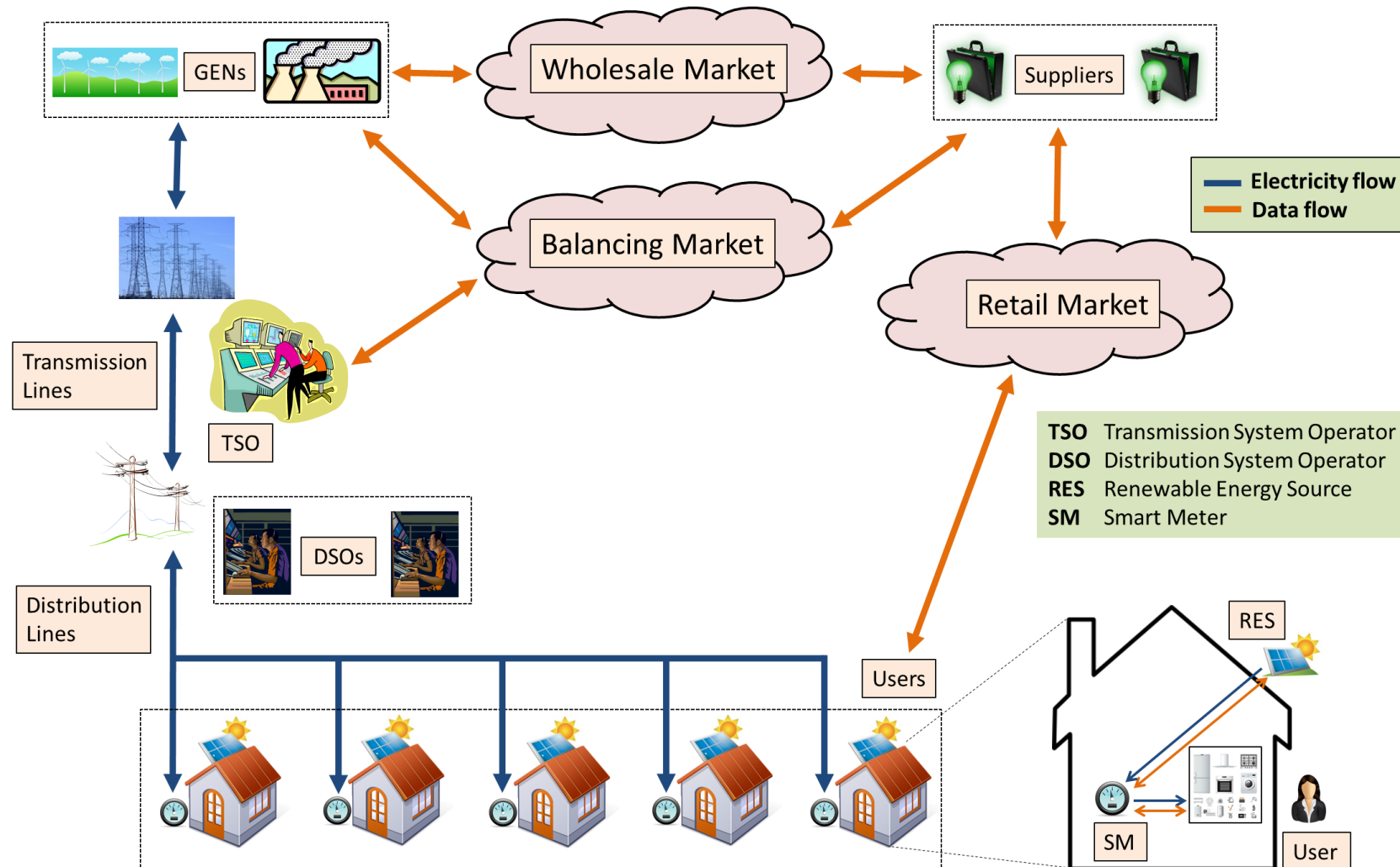
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# Outline

- Current electricity markets
- P2P electricity trading market
- Trading scenarios
- Security & privacy analysis
- Conclusions

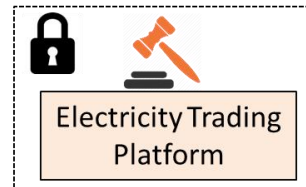
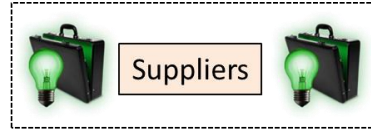
# Current electricity markets



# The situation now

- Users (households and SMEs)
  - are obliged to buy electricity from their suppliers
  - are not allowed to trade electricity among themselves
  - receive small (or no) payments for electricity fed to the grid
    - no payments in Flanders (Belgium)
    - some payments – e.g., in the UK
      - the export tariff is **0.047** £/kWh (in 2017)
      - the average import (i.e., retail) price is **0.139** £/kWh (in 2017)
- Suppliers are the only players that can sell electricity to users

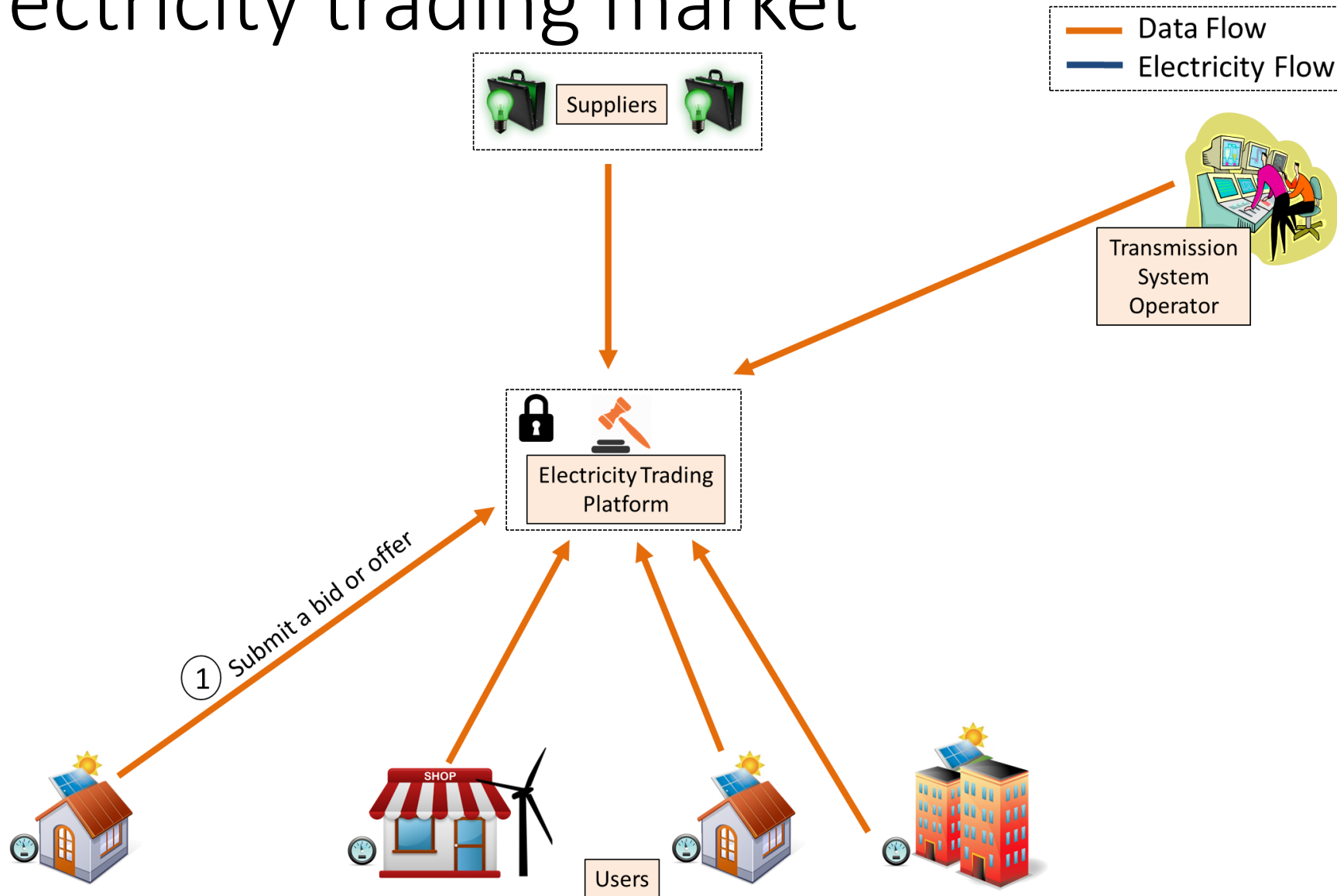
# P2P electricity trading market



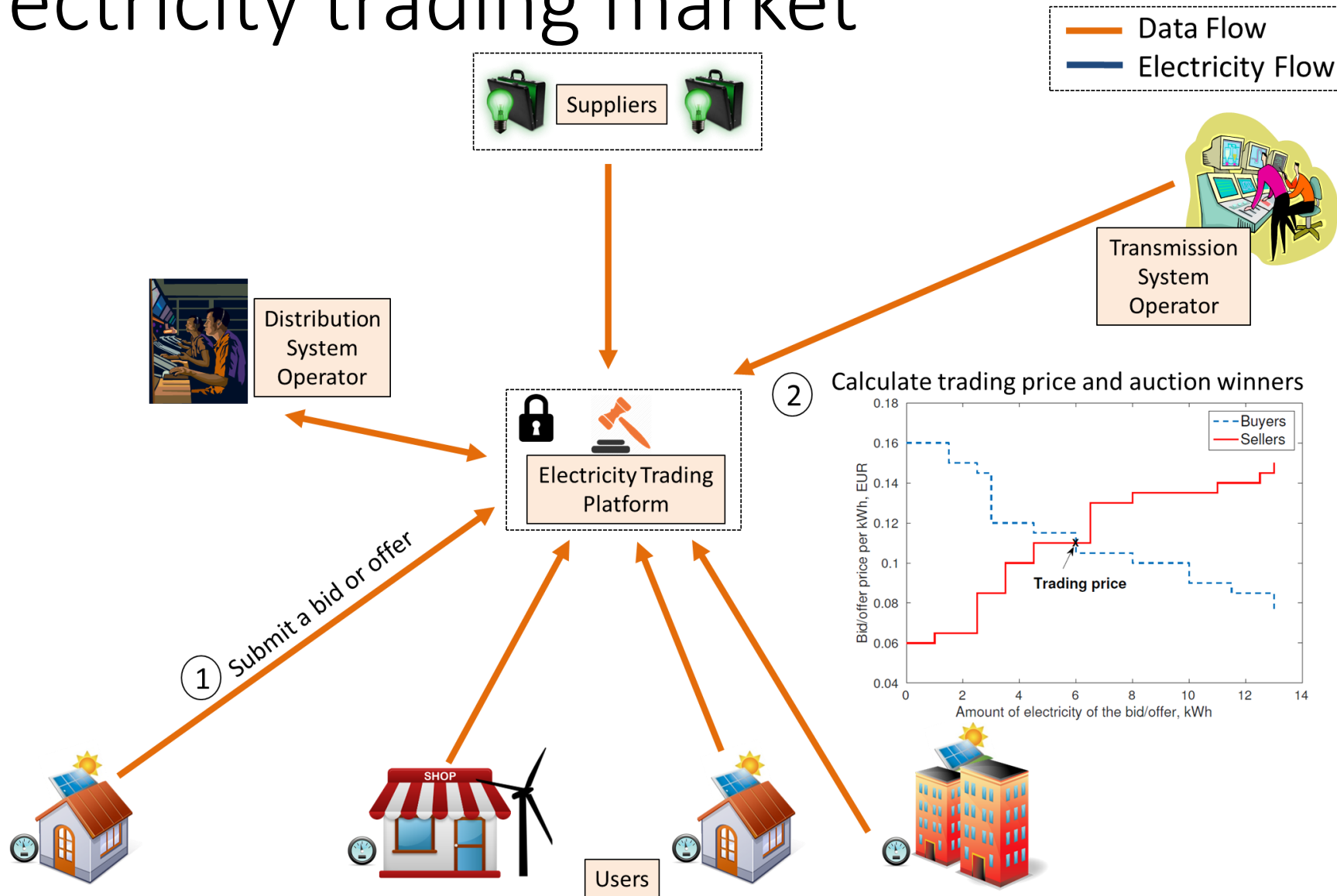
Users



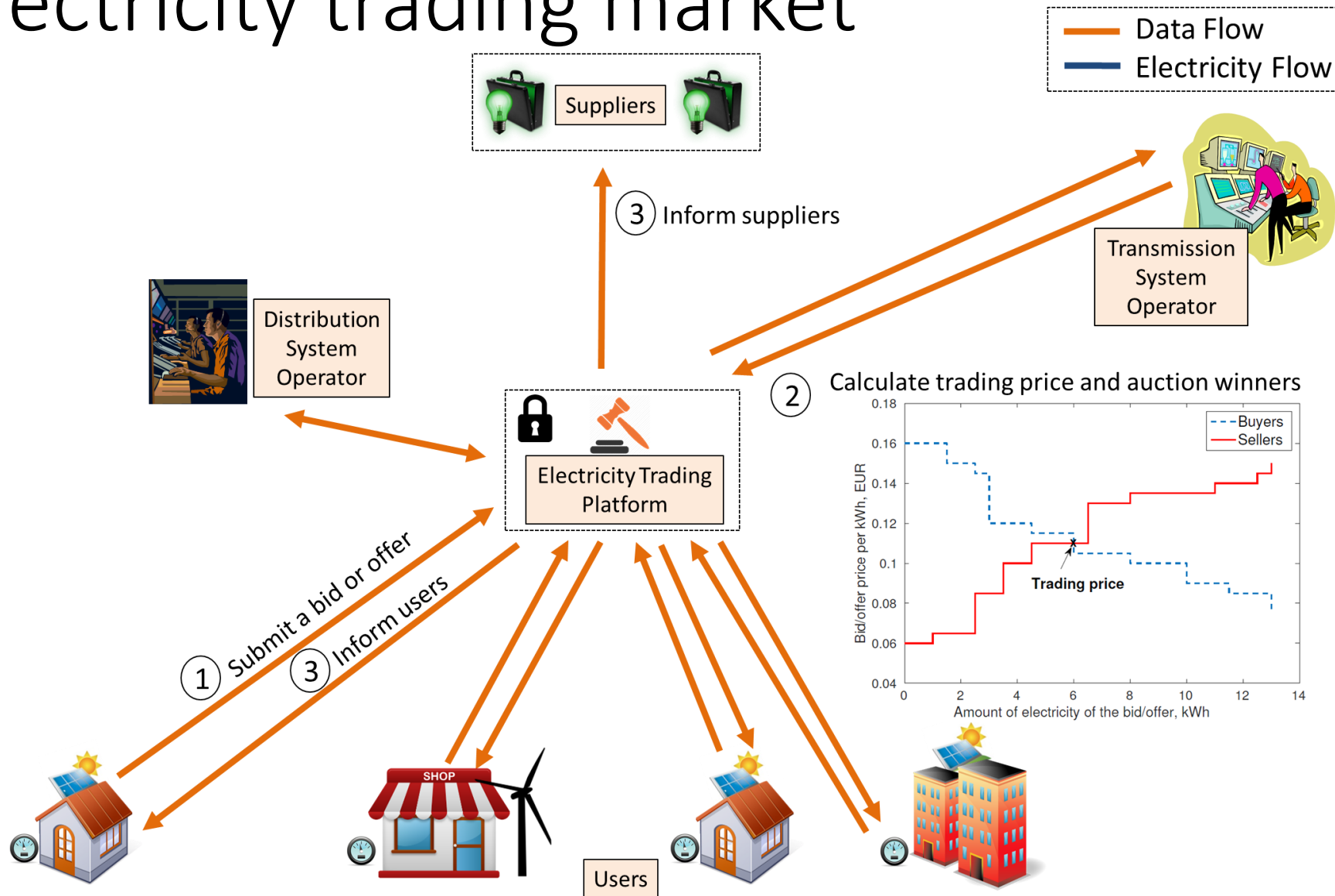
# P2P electricity trading market



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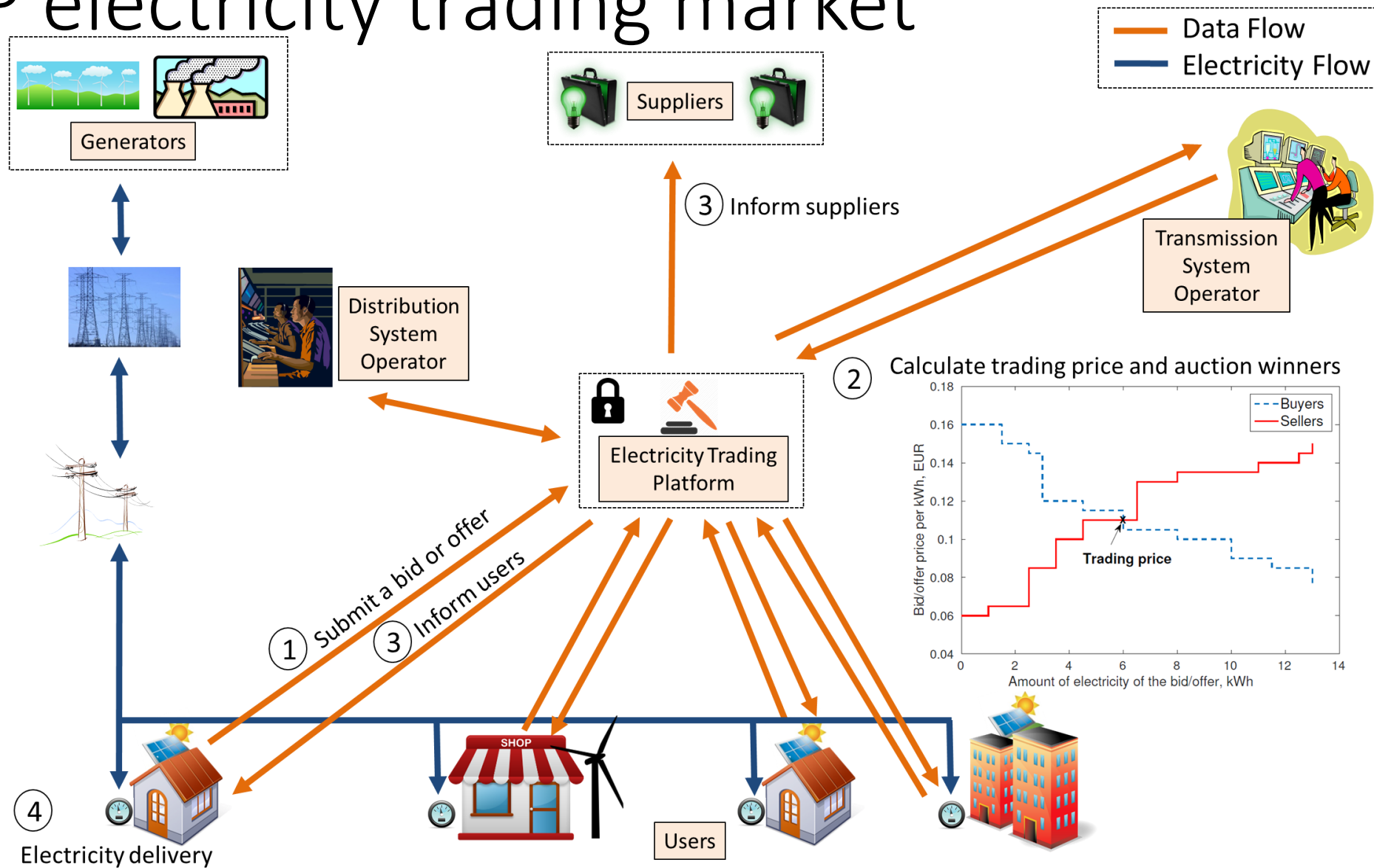


# P2P electricity trading market

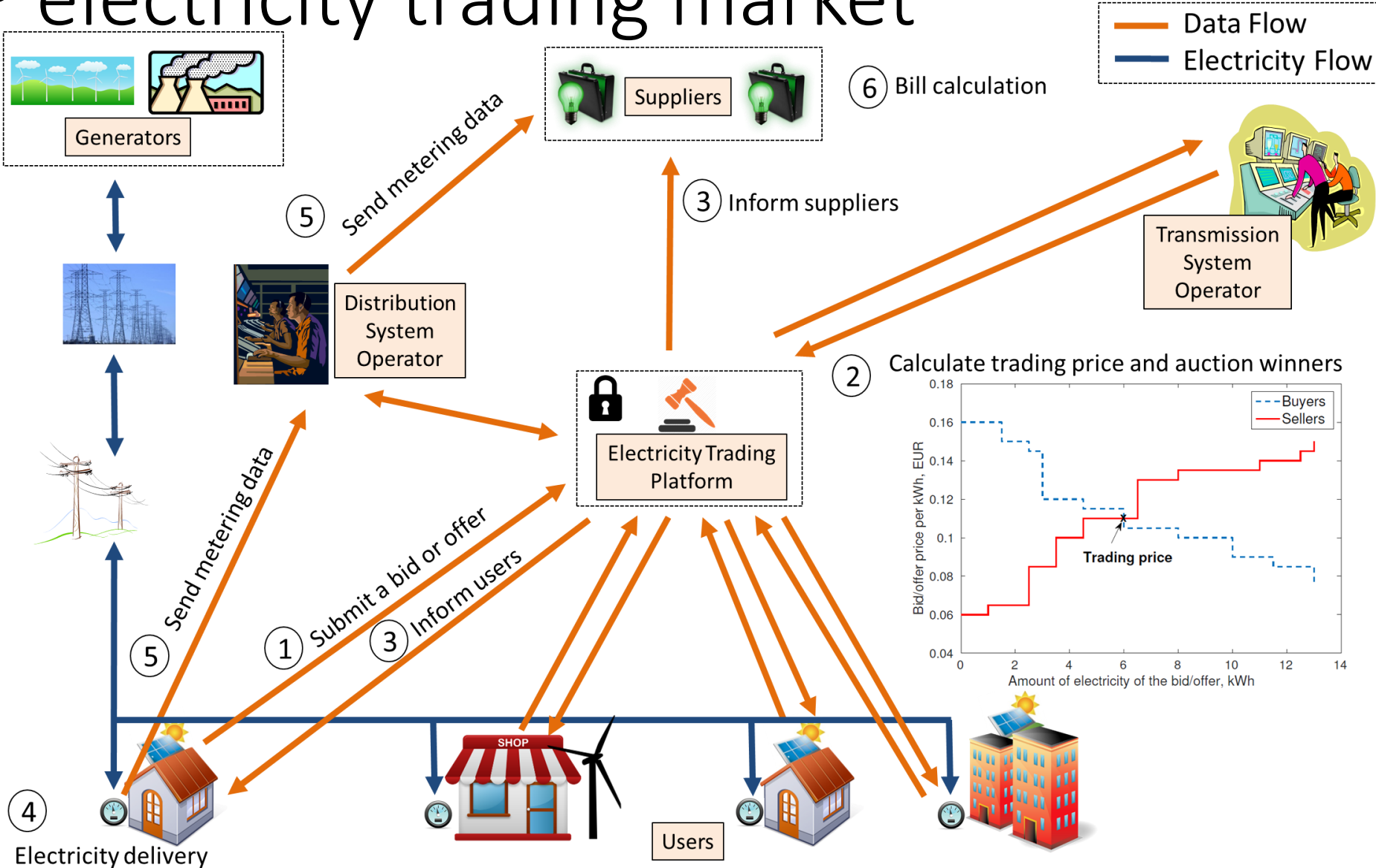




# P2P electricity trading market



# P2P electricity trading market



# Scenario building

The scenario analysis is aimed to answer the following questions.

- What would the electricity market look like in the future in the case of p2p electricity trading?
- How the existing roles change, disrupt, or disappear?
- Which new roles and actors emerge in the electricity market?
- What opportunities for sharing economy exist in the future electricity market?

# Business model matrix

To identify the *most important uncertainties* about value creation and control issues in the future electricity market, business model matrix is used. Two main categories, value and control parameters, build the business model matrix.

CONTROL PARAMETERS				VALUE PARAMETERS			
Value Network Parameters		Functional Architecture Parameters		Financial Model Parameters		Value Proposition Parameters	
<b>Combination of Assets</b>		<b>Modularity</b>		<b>Cost (Sharing) Model</b>		<b>Positioning</b>	
<i>Concentrated</i> → <i>Distributed</i>	<i>Modular</i>	<i>Integrated</i>	<i>Concentrated</i> → <i>Distributed</i>	<i>Complement</i> → <i>Substitute</i>			
<b>Vertical Integration</b>		<b>Distribution of Intelligence</b>		<b>Revenue Model</b>		<b>User Involvement</b>	
<i>Integrated</i> → <i>Disintegrated</i>	<i>Centralised</i>	<i>Distributed</i>	<i>Direct</i>	<i>Indirect</i>	<i>High</i>	<i>Low</i>	
<b>Customer Ownership</b>		<b>Interoperability</b>		<b>Revenue Sharing Model</b>		<b>Intended Value</b>	
<i>Direct</i>	<i>Intermediated</i>	<i>Yes</i>	<i>No</i>	<i>Yes</i>	<i>No</i>	<i>Price/Quality</i>	<i>Lock-in</i>

# Emerging roles

- **Prosumers:** The role of a prosumer is a concoction of a local electricity producer and consumer.
- **Broker:** This is an intermediate actor that facilitates (i.e., supports prosumers to perform) trading in the p2p electricity market. The role of a broker can be played by the grid operators.
- **Representatives:** They manage their clients' assets (i.e., battery, solar panels, flexibility) and information as well as represent them in electricity markets (including the p2pmarket).

# Scenarios

S1 Direct peers: Active citizens and direct customer ownership, involving only **prosumers**.

S2 Direct customers: Passive citizens with direct customer ownership, involving **prosumers** and **representatives**.

S3 Indirect customers: Passive citizens with intermediated customer ownership, involving **prosumers**, **representatives**, and a **broker**.

S4 Indirect peers: Active citizens with intermediated customer ownership, involving **prosumers** and a **broker**.

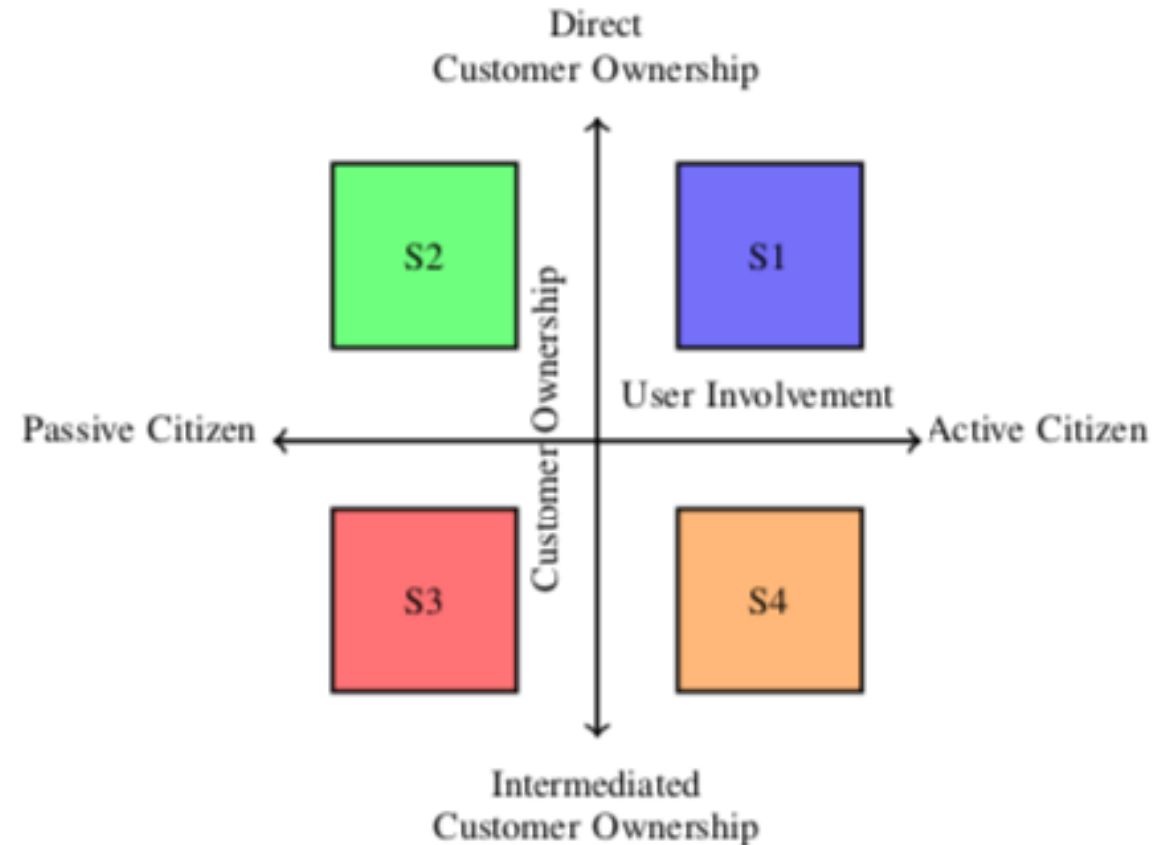
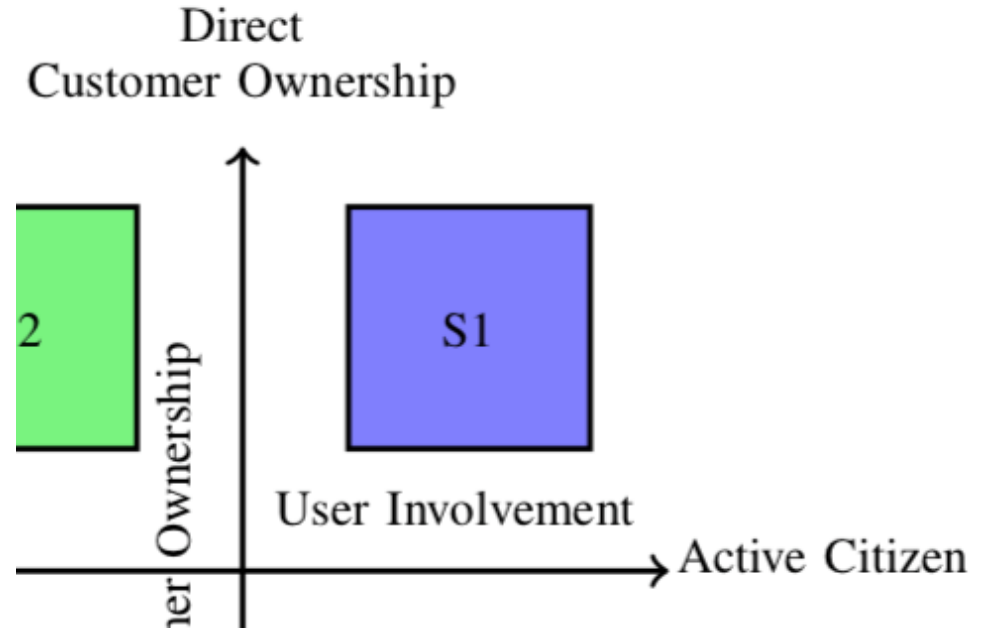
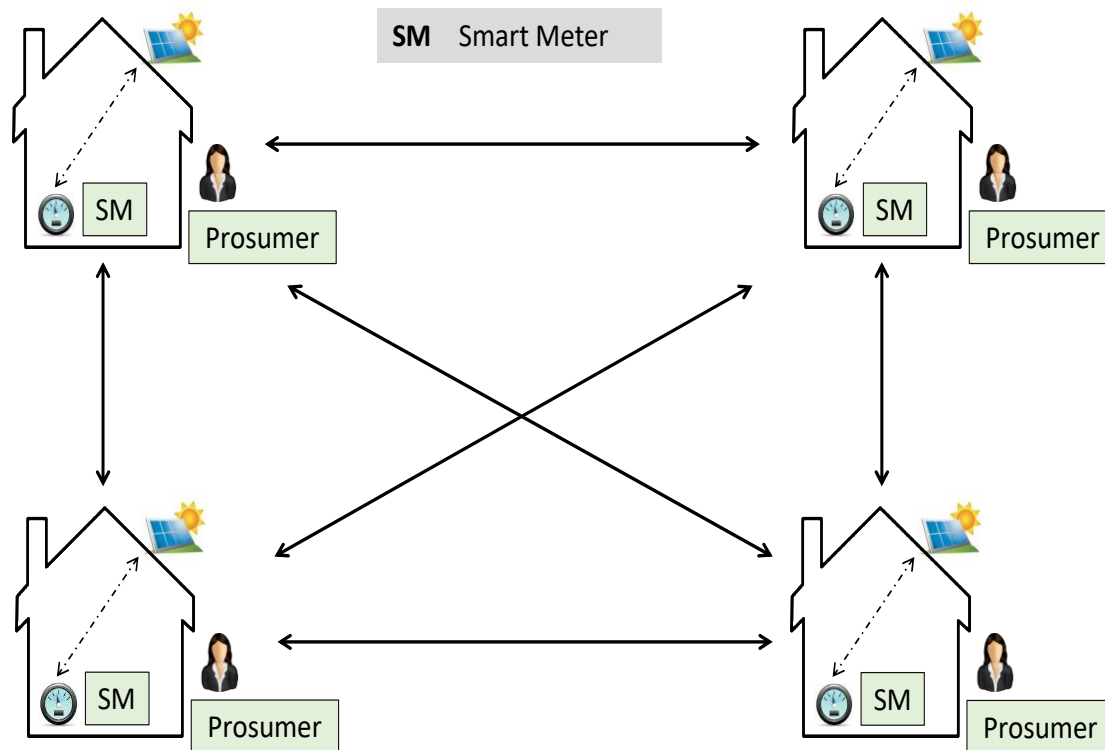


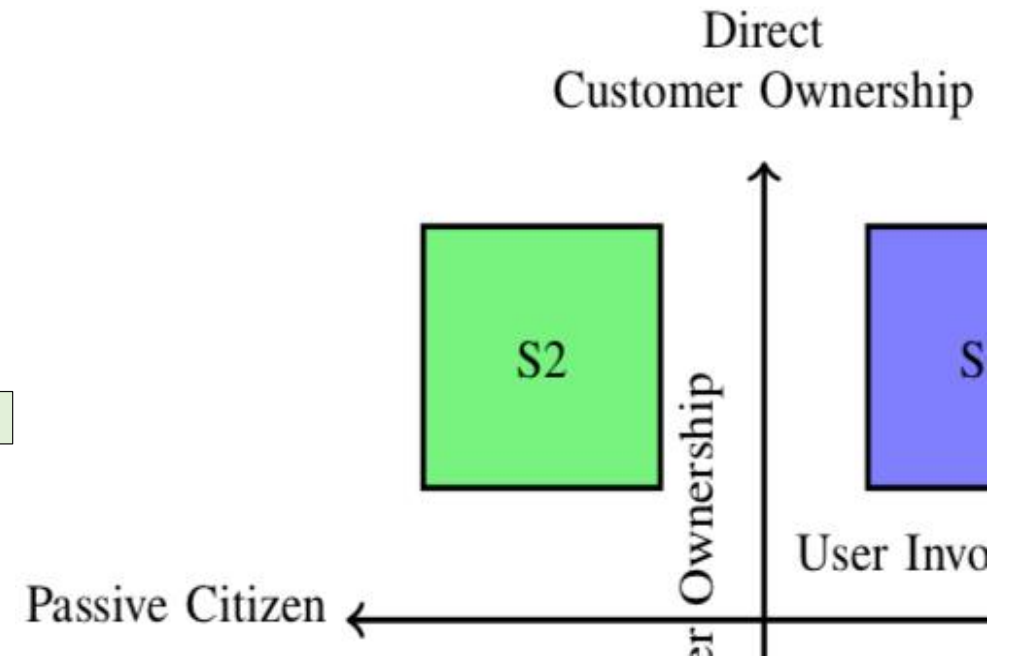
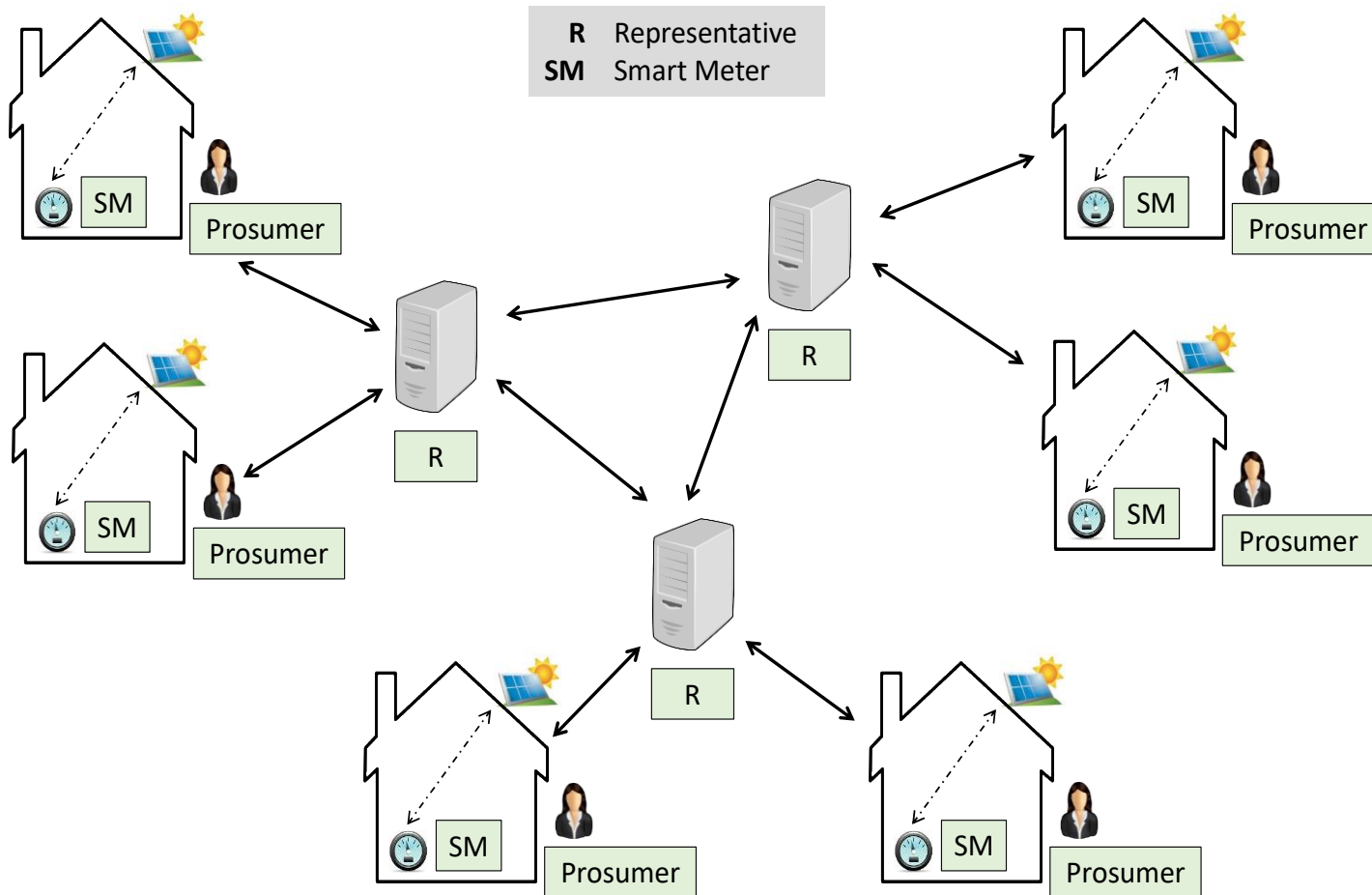
Fig. 1. Future scenarios based on two key uncertainties: customer ownership and user involvement.

# Scenario 1



1. Citizens actively participate
2. Active prosumers directly contact and trade electricity with each other

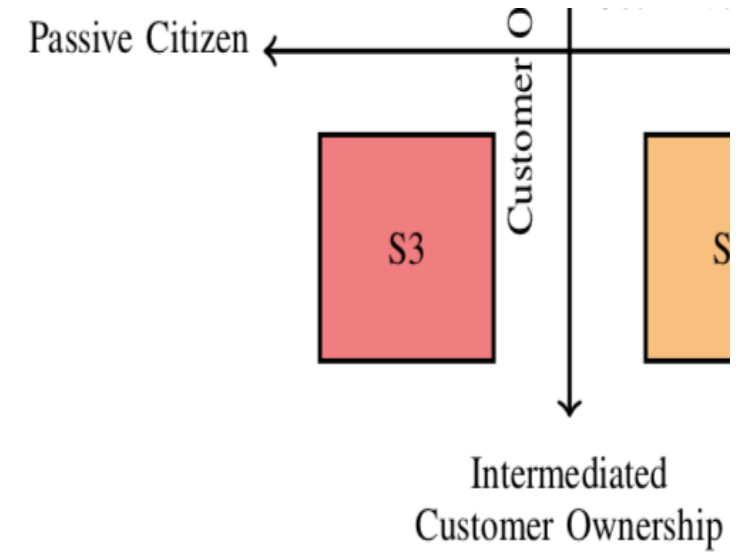
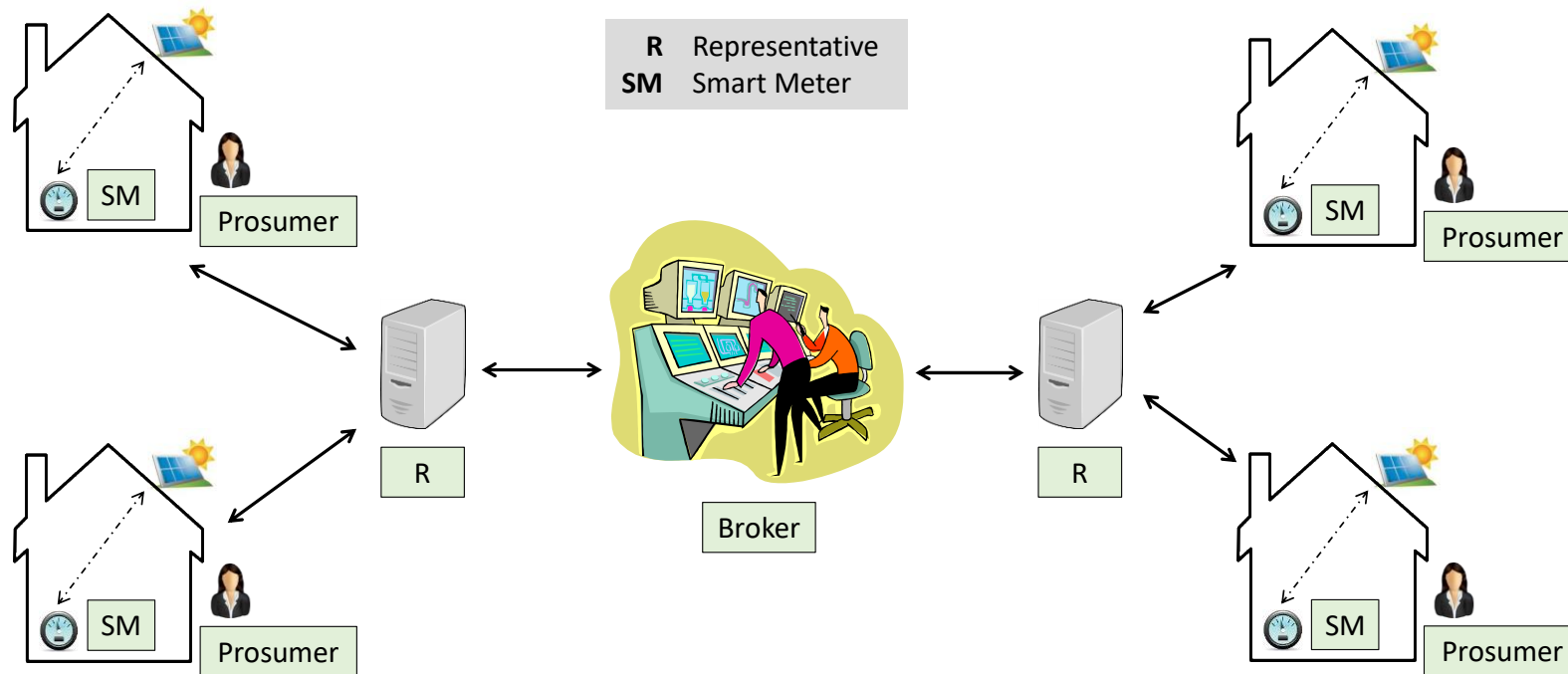
# Scenario 2



1. Citizens are not actively involved in trading with each other despite having the possibility to do so.
2. Representatives trade on the p2p electricity market on their behalf

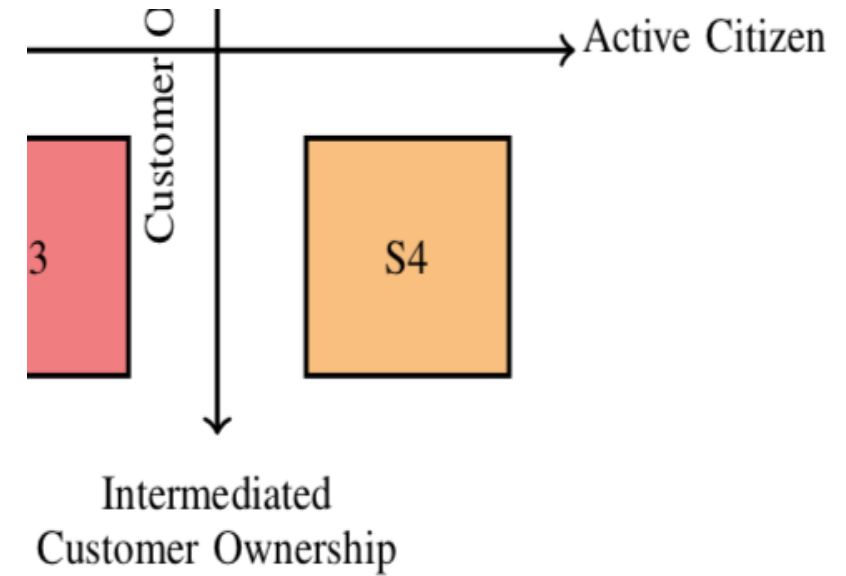
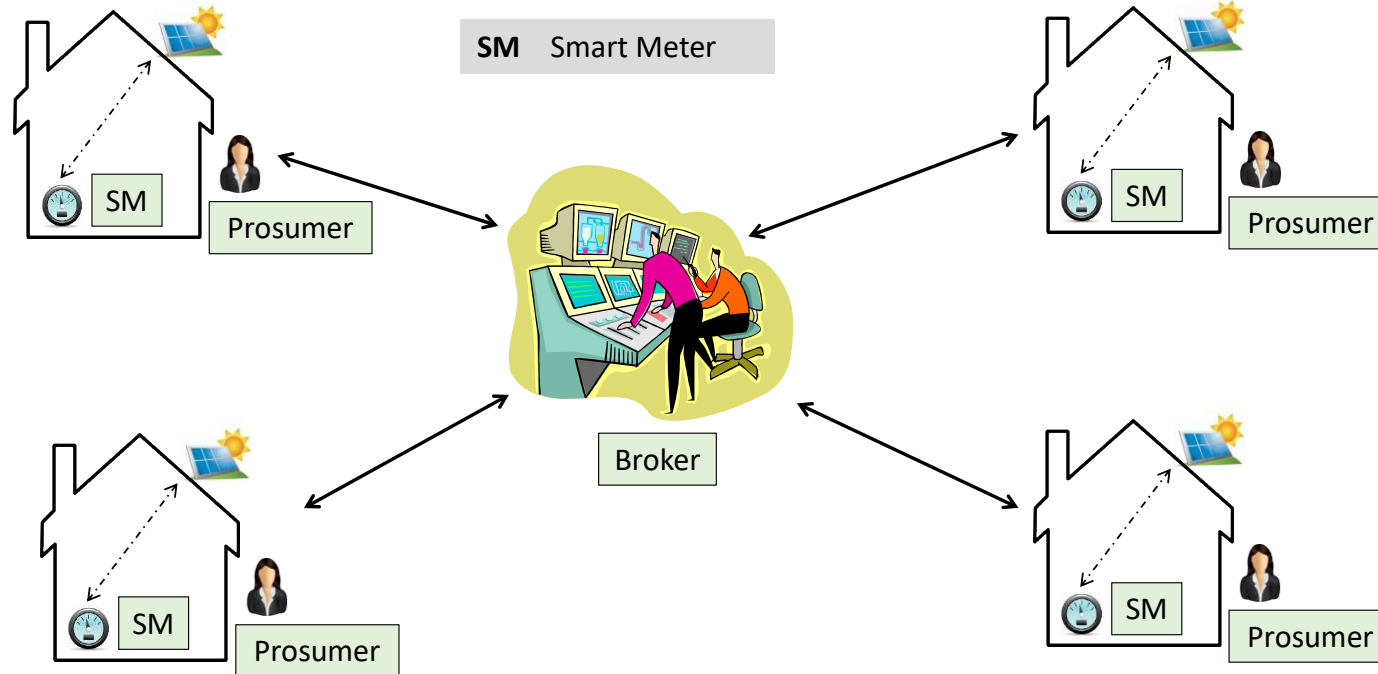


# Scenario 3



1. Citizens are not actively involved in trading
2. Broker is in contact with the representatives of prosumers

# Scenario 4



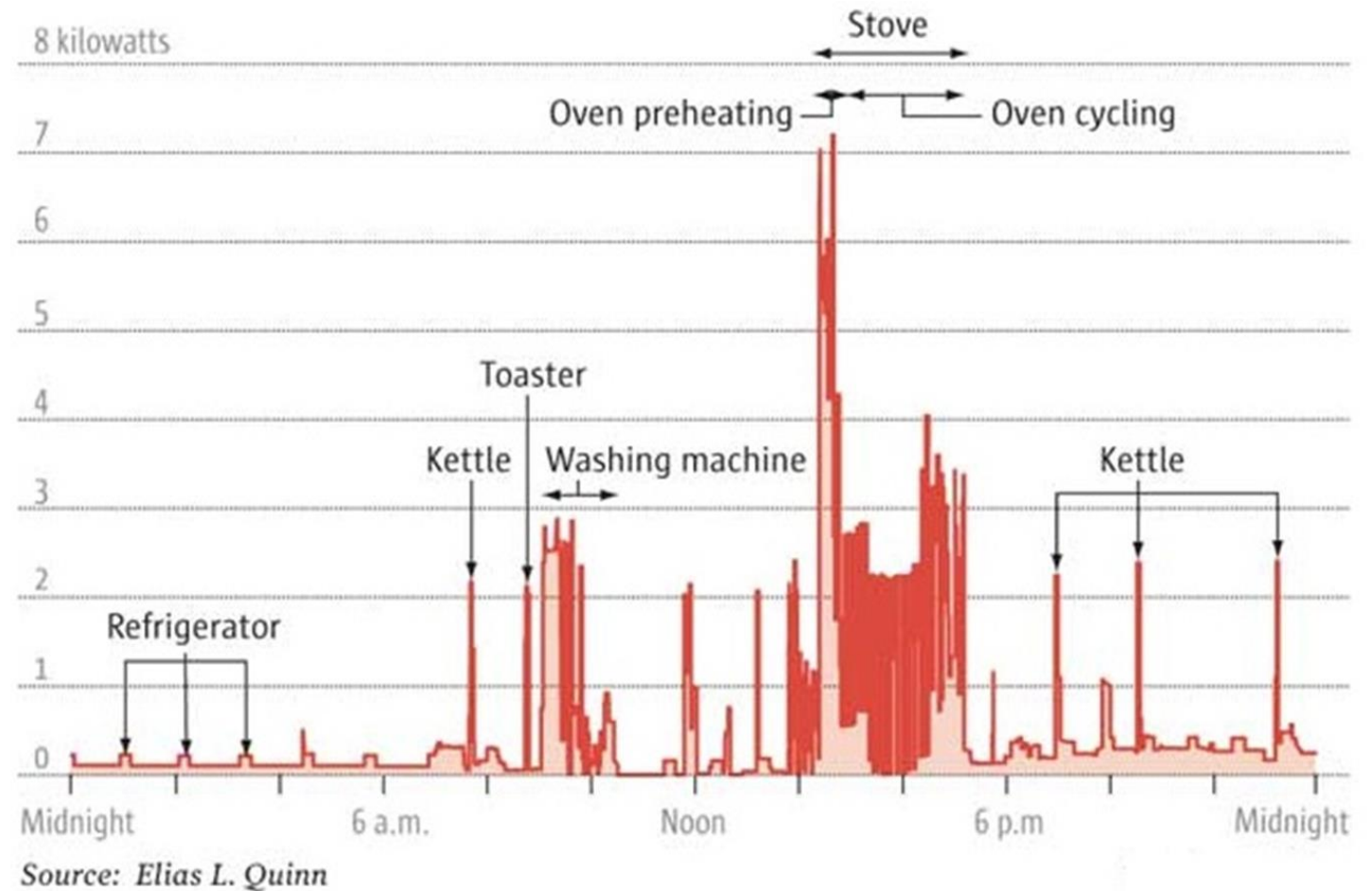
1. Citizens are actively involved in trading their electricity via an intermediary
2. Broker is in contact with consumers and prosumers

# Security and privacy analysis: all scenarios

- Impersonation -> Authentication
- Data manipulation -> MACs, Digital Signatures
- Eavesdropping -> Encryption, e.g., AES
- Disputes -> Digital Signatures

# Security and privacy analysis: all scenarios

- **Who, when and how much** electricity is selling or buying



# Security and privacy analysis: Scenario 1

- Sybil and DoS attacks -> Authentication, secure congestion policing feedback [LYX10, ACM SIGCOMM]
- Disputes, double spending -> consensus protocol to agree on a final state (PoW, PoS, etc.)
- Note: PoW might be too inefficient for p2p electricity trading applications

# Security and privacy analysis: Scenario 3

- Broker is a single point of failure -> Requirement of distributed storage (IPFS, etc. )
- DoS attacks -> secure congestion policing feedback
- Inference attacks by Broker -> aggregated inputs by representatives, homomorphic encryption, multiparty computation

# Conclusion

- Applied business model matrix to identify the most important uncertainties in future p2p electricity markets
- Used user involvement and data ownership to define four scenarios
- Performed threat analysis on each of the defined scenarios
- Specified security and privacy requirements

# Thank you! Questions?

