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# Investigation of Flexible Pricing in Smart Energy Grids Using Multi-Agent Simulation

## Background

Very complex systems, such as an energy system, cannot be analysed or modelled using "classic" approaches, such as equation systems or linear programming. Three major aspects that cause this complexity are:

- Self-organization: A system does not always contain a leader/controller who coordinates the overall behaviour of the actors. Instead, actors might organize themselves spontaneously in a way that causes order in the system.
- Non-determinism: Individual actors in the system only possess, and can only respond to, partial knowledge about the system. Furthermore, a considerable of randomness arise due to the individual actors' spontaneous behaviour.
- Dynamic system topology: The behaviour of individual actors in the system and their influences on each other might change radically depending on certain conditions. Actors might be appear and disappear entirely.

The multi-agent modelling approach can help model the dynamics of a system that features the above properties. Simulation is far more intuitive and treats the individual agents (or populations hereof) as separate objects who interact and affect each other and their environment, each agent following their own set of rules.

## Objectives

By simulating the introduction of flexible energy price schemes on different types of energy in a chosen energy grid, several questions are sought to be answered, including, but not limited to:

- Investment costs/barriers: Are there any investment costs that prevent the or inhibit the solution from being adopted?
- Response: How and how quickly will the different actors in the system adopt the solution or respond to the change?
- Long-time prospects: Will the system reach a point where it is in equilibrium or will it keep oscillating/develop randomly due to certain feed-back mechanisms?
- Who benefits?: How much value will be created for the different actors in the system? Will relocation of value between some of the actors be necessary to facilitate the adoption of the solution/faster response of the system?

## Methodology

The multi agent-based software simulation platform, AnyLogic, will be used for the modelling. AnyLogic is very flexible and can be used for many different types of systems. It also provides System Dynamics and Discrete Event modelling functionality which can be combined with the agent-based modelling. This can be very useful for defining the individual behaviour of the agents.

Input data and information about the behaviour and preferences of the energy system actors is gained through:

- Interview/cooperation: The major and unique actors in the system, e.g. energy distributors, large producers and consumers and relevant technology companies
- Surveys: Smaller and relatively homogenous groups of energy producers and consumers which can be clustered into populations