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**title: Mini-Lecture 7.1 -- Agents in energy systems models**

keywords:

- Agent-based model

authors:

- Alexander J. M. Kell

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In this mini-lecture we will describe the importance of agents within MUSE and also within an energy systems modelling context.

# Learning objectives

- Understand why agents are important in an energy modelling context

- Understand how we can characterise these agents within MUSE

# Agents overview

Within real-life energy systems there are many different objectives that investors or consumers have. These objectives may differ by sector, by investor type or by proportions of the population. For instance, a certain percentage of the population may be willing to be spend more money on heating their homes than others.

It is straightforward to specify these objectives and characteristics within MUSE. For instance, you may want to split a population based upon their geospatial and economic characteristics. This could be done by, for example, splitting a population into rural and urban categories. That would provide us with two groups. However, it is possible to go further, and we may want to split the rural and urban groups into different socioeconomic demographics, such as disposable income.

Say for example, we only split the population into rural and urban. We can specify these groups as two agents within MUSE. Once we have specified the two agents, we would have to give them characteristics which differentiate them from the each other and define the proportion of the population that they make up. It must be noted, at this stage, that we do not need to have a separate agent for each individual or entity. It is perfectly fine to group and aggregate similar individuals or agents.

# Summary

In this mini-lecture we understood the concept of agents and how they relate to an energy modelling context. We briefly understood how we can translate these concepts into MUSE. Urban populations might have greater energy needs or rural populations may not have access to the same energy sources. Giving the model a bit more detail will allow you to make sure that the model is both more accurate, and that its projections take into account different parts of society. In the hands-on we will learn how to add a new agent.

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**title: Mini-Lecture 7.2 -- How to relate agent representations to the real world**

keywords:

- Agent-based modelling

- Characterisation

authors:

- Alexander J. M. Kell

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In this mini-lecture we will introduce some methods to translate socioeconomic data into MUSE with a quantitative approach.

# Learning objectives

- Discuss surveys and socioeconomic data and how these can relate to MUSE

- Discover ways that surveys can be used in quantitative modelling

# Qualitative representation in agent-based models

Through the use of qualitative data, such as using qualitative surveys, it is possible to gain greater insight into the different characteristics of consumers or investors. One example of how this can be done was by Moya et al. (2020). In this paper the authors explore fuel-switching investment in the long-term energy transitions of India's industry sector. They inform the modelled agents through a questionnaire that was carried out to inform MUSE.

Some of the types of questions asked in the questionnaire to industrial companies are listed below:

- Geographical location

- Financial details

- Investment plans

- Type of fuels used

- Willingness to switch fuels

Once these data have been collected, they can be used to find similar groups of investors and to start characterising the agents. For instance, if from the data it is clear that geographical location is an important consideration, the decision could be made to group companies by geographical region and form an agent on this basis. If the more important consideration is the investment plans, then a group can be made there.

This approach is a more than efficient method of better understanding the characteristics of agents of a system, and it can help to inform a better modelling process. The work by Moya et al. ([@Moya2020]) finds that the results represent the unique heterogeneity of fuel-switching industrial investors with distinct investment goals and limited foresight on costs. In other words, the survey results have an impact on the outcome of the energy system over the long-term.

# Summary

In this mini-lecture we explored how surveys can be used to inform agents within MUSE. We also discovered how these results can affect the modelling outcomes of energy systems.

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**title: Mini-Lecture 7.3 -- Agents by sector**

keywords:

- Sectors

- Agent differentiation

- Key agent parameters

authors:

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In this mini-lecture we will cover how agents and their characteristics can differ between sectors. We will also investigate the similarities between agents and sectors and consider the key parameters that make up agents.

# Learning objectives

- Understand the differences between agents of different sectors

- Understand the key parameters that differentiate agents

# Agent parameters

Different sectors may mean having agents with different characteristics. For instance, within the residential sector socioeconomic data can be used to characterise the agents. We could use wealth to characterise our agents in different geographic locations. For example we could place a constraint on the `Budget` parameter for residential users, and split these agents into different proportions. For example, we could prohibit 70% of residential users from spending more than a certain amount on heating which could affect their technology choice. The other 30% of users would form an agent that was not constricted in this way, and thus their choices may end up being differet in the model.

Another way we could classify residential agents is through the `Maturity` parameter. This would limit investments in novel technologies until the specified technology had a certain market share. This could be informed by the innovation adoption lifecycle, as shown by Figure 7.3.1. Where, for example, innovators make up 2.5% of the population but have no `Maturity` constraints. As we work our way up the curve from innovators to laggards, this `Maturity` constraint increases.

![](assets/Figure\_7.3.1.png){width=100%}

\*\*Figure 7.3.1:\*\* Innovation adoption lifecycle

# Sectors

In this mini-lecture we have focused on the residential sector and seen the way we can characterise agents. Although these characteristics may not directly translate to the power sector, in some cases investors in the power sector can have similar characteristics. For instance, some companies are larger, and are more willing to invest their capital, reflecting a larger `Budget` parameter. Others may be less willing to invest in new technologies. The differing objectives of agents will often be the reason behind differences with other agents. For instance, some agents may only want to minimise their costs, whereas others may want to reduce their capital expenditure. It is easy to change these characteristics within MUSE to create diverse energy scenarios.

# Summary

In this mini-lecture we covered the differences between agents and the different parameters that can be used to inform these differences. We saw how the `Maturity` constraint maps to the innovation adoption lifecycle and how the `Budget` parameter can be informed by socioeconomic characteristics. These parameters lead to a large amount of possible scenarios that can be tested and run.

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**title: Mini-Lecture 7.4 -- Agent parameters**

keywords:

- Agent parameters

- MUSE

authors:

- Alexander J. M. Kell

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This mini-lecture explores all the major parameters that can define agents within MUSE.

# Learning objectives

- Understand the different agent parameters and their role within MUSE

# Overview agent parameters

Within MUSE each agent can have their own objectives. MUSE is flexible enough to allow for up to 3 objectives, which can be summed together at various weightings. To input these objectives into MUSE one would use the `Objective1`, `Objective2` and/or `Objective3` parameters and select an objective such as `comfort`, `lifetime\_levelized\_cost\_of\_energy` or `fixed\_costs`.

Then we would select the weight of each of the objectives using the `ObjData1`, `ObjData2`, `ObjData3` inputs. For example, if we had 3 objectives, we could make the objective of `Objective1` dominant by setting `ObjData1` to 0.5. This would mean it would make up 50% of the final objective.

We can edit the `SearchRule` to reduce the space of technologies that those agents are likely to consider. For example, we could fill this with `same\_fuels`, or `same\_enduse`.

The rest of the parameters include the parameters discussed in the previous lecture:

- `MaturityThreshold`

- `Budget`

# Summary

In this mini-lecture we discovered the main parameters that are used by agents within MUSE. For a full breakdown of the parameters please refer to the MUSE documentation that can be found online.