**MUSE-SGI Non-Technical Overview**

**Residential and Commercial Building Sector Module**

# Context

Buildings account for almost a third of final energy consumption globally and are an equally important source of CO2 emissions [1].

There are significant opportunities and challenges to decarbonise this sector. For example, heating end-uses are highly reliant on fossil fuels while the cooling demand is growing rapidly both in OECD and in emerging countries with highly carbon-intensive electricity systems (e.g. India and China).

Recent major advances in building design, know-how, technology, and policy have made it possible for global building energy use to decline significantly [2]. However, in view of the increasing energy demand in the building sector, technology innovation and spread of renewables will be necessary to achieve a low-level energy performance [2].

# Problem Statement

The residential and commercial building sector module, RCBSM, includes residential as well as commercial buildings. It is designed to estimate the energy service demand due to households and services based on key macroeconomic driver projections. Furthermore, it simulates technology investment decisions and determines the demand of fuels on a global scale, disaggregated into regions and temporally resolved into timeslices to fulfil the energy services. For an accurate modelling of the technology choice for new investments, a realistic consumers’ behaviour towards technological change needs to be included to simulate real-world decision-making. Therefore, the RCBSM needs to be technology-rich as well as appropriately informed with the macroeconomic drivers which best represent the trend of energy service demand on a regional scale. It uses a bottom-up approach to model technologies on both technoeconomic and environmental aspects.

# Module Approach

The RCBSM is a global simulation model with the aim to predict the future end-use demand, to determine the required fuel demand and to model investment decisions to represent real consumers' behaviour in the market. The energy demand of the sector is disaggregated in different end-uses such as lighting, appliances, cooking, space heating, water heating, cooling, and cooking. The projections for these energy end-uses are carried out on a global scale using a regional disaggregation into regions and a time series of macroeconomic drivers.

The RCBSM is based on a two-step simulation approach. First, the service demand is dynamically calculated using macroeconomic drivers. Then a merit-order approach based on equivalent annual cost is used to determine the technology market share, and the corresponding fuel mix. Among the factors that also play an important role in the investments made in this sector, are the fuel mix of the already installed equipment in a household or the maturity of the technology. In order to take people’s attitude towards technologies and technological changes into account as well as the effects of policy, the RCBSM applies a bottom-up approach to the technology characterization, based on unit technology cost, efficiencies, lifetime as well as emissions.

# Relationship with MUSE Modules

The RCM module dynamically exchanges a set of variables with the Market Clearing Algorithm (MCA) in MUSE to determine the fuel demand in every modelled region per time period and timeslice. A snapshot of the data workflow for a generic iteration in a generic time period, timeslice and region is shown in Figure 1.

The module uploads exogenous parameters for the techno-economic and environmental characterisation of each technology type per region in the base year as well as projected improvements in the next simulation periods. The full data exchange protocol between the RCM and the next modules in MUSE is in Table 1.

RCM

MCA

**Exogenous Inputs:**

Macroeconomic driver,

assumptions on policies,

cost by asset type,

efficiencies by asset type,

environmental emissions,

operational constraints by asset type,

existing stock by asset type and retirement profile

**Specific Outputs:**

aggregate CAPEX,

aggregate OPEX,

production by asset type, emissions by asset type,

capacity by asset type

forward prices of fuels,

forward carbon price

demand for fuels,

emissions

Figure 1: Major interactions between RCM and the rest of MUSE

Table 1: Description of the data exchange protocol for the RCM.

|  |  |
| --- | --- |
| RCM Key Inputs | RCM Key Outputs |
| MUSE core dynamic variables* Forward fuel price for each time period with timeslice disaggregation (MUSD2010/PJ)
* Forward carbon price (MUSD2010/GtCO2)

RCBSM-specific input parameters* Techno-economic and environmental characterisation (conversion efficiency, unit investment and operating costs, GHG emissions and F-gases emissions) of each end-use technology in each time period and region
* Existing end-use technologies for the model base year by technology type, including their retirement profile
* Macroeconomic drivers and policy assumptions
 | **MUSE core dynamic variables*** Forward emissions for each time period, region and timeslice (GtCO2/year)
* Forward primary fuel demand for each time period, region and timeslice (PJ/year)

**RCBSM-specific outputs*** Investment and retirement in capacity terms by time period, technology type and region
* Aggregate CAPEX and OPEX by time period, timeslice and region
 |

# References

1. IEA, Technology Roadmap Energy-efficient Buildings: Heating and Cooling Equipment, 2011.
2. The Global Energy Assessment (GEA) Toward a Sustainable Future, Chapter 10 : Energy End-Use: Buildings, 2016.