

WESOM | *Brief introduction*

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Brief description: purpose, model concept and main features

The Wuppertal Energy Supply Optimisation Model (WESOM)¹ is a model to support the long-term planning and evaluation of energy systems. It models and evaluates cost-optimised supply structures for energy carriers such as electricity or hydrogen on a system-wide basis, taking into account exogenous conditions such as greenhouse gas (GHG) emission limits. It maps the generation or production, storage and transport of energy carriers in corresponding production facilities, storage facilities and transport infrastructure in a spatially and temporally differentiated manner. As a result, the model shows the necessary expansion and operation of production facilities, storage facilities and transport infrastructure to meet energy demand in a cost-optimised manner.

Model architecture and data handling

WESOM is formulated as a linear optimisation model and is based on the Open Source energy MOdelling SYStem (OSeMOSYS), an open-source framework for energy system planning. Parameters represent the model's input data; variables represent the results.

The key parameters (input data) for WESOM are:

- Level of demand for energy carriers
- Temporal and spatial distribution of demand for energy carriers
- Temporal and spatial data on the potential of renewable energy (RE) sources and RE feed-in time series
- Techno-economic parameters, such as costs and efficiencies
- Minimum and maximum requirements for the expansion and operation of production facilities, storage facilities and transport infrastructure
- GHG emission limits

The key variables (results) of WESOM are:

- Spatial and time-differentiated data on the installed capacities and operation of production facilities, storage facilities and transport infrastructure
- Investment and operating costs associated with expansion and operation
- GHG emissions of the energy system

¹ WESOM was initially known as the Wuppertal Institute System Model Architecture for Energy and Emission Scenarios – Energy Supply Model (WISEE-ESM) before being renamed WESOM in 2025. WISEE-ESM was divided into two modules: WISEE-ESM-I for investment optimisation and WISEE-ESM-D for dispatch optimisation. WESOM corresponds to WISEE-ESM-I.

The objective function of WESOM minimises the total system costs of the modelled energy system. The constraints take into account energy and mass balances (e.g. energy demand must be met in all regions at all times) and capacity restrictions, (e.g. renewable energy technologies may only be expanded up to their potential limits).

The system boundary of the model in terms of modelled energy carriers and technologies, as well as in terms of temporal and spatial resolution, can be adjusted for each application by using appropriate input data. The model can be configured to specific requirements depending on the issue at hand. For example, the user can specify that the model should: divide Europe into 30 regions; take account of electricity, hydrogen and fossil fuels as energy carriers; and operate with six reference years and 384 hours per year.

WESOM features automated data preparation. This is designed to process input data, maintained in a database for use in the model, according to a configuration specified by the user. Key data preparation functions include regionalisation, spatial and temporal aggregation, and handling of data gaps.

Model application and examples

A cost-optimised energy supply model such as WESOM can help answer a variety of research questions. Classic questions concern issues including cost-efficient transformation pathways to achieve climate targets (see Example 1). However, combining WESOM with other methods makes it possible to answer other questions related to energy system transformation (see Example 2).

Example 1: Modelling of synthetic fuel production pathways in the MENA-Fuels project

The MENA-Fuels project served to develop roadmaps for the production of sustainable synthetic fuels in the MENA region to support the decarbonisation of transport in Germany. In a sub-project titled “Potential and infrastructure analysis for renewable electricity, hydrogen and synthetic derivatives”, WESOM was used to calculate cost-optimised scenarios for supplying Europe with electricity, hydrogen and synthetic fuels, taking into account the MENA region. The model was tailored to take account of Europe, the Middle East and North Africa. It included a wide range of technologies for the production of synthetic fuels and intermediate products as well as a variety of transport options. The time horizon spanned from 2030 to 2050.

Example 2: Assessment of potential lock-in paths in the NoRaLockH₂ project

The NoRaLockH₂ project aims to identify framework conditions suitable for establishing a sustainable hydrogen economy. This project uses WESOM in conjunction with the agent-based AMIRIS model from the German Aerospace Center (DLR). As a cost-optimising model, WESOM provides initial calculation of a reference pathway for development of a hydrogen economy in Germany and Europe by 2045. The AMIRIS model simulates investment in hydrogen production under different framework conditions in Germany. WESOM takes the resulting capacities and

optimises them from these starting points. Comparing the costs of the resulting pathways with the reference pathway makes it possible to assess whether each set of framework conditions is suitable for contributing to the sustainable development of a hydrogen economy – or whether they could generate lock-in effects.

The following publications and project reports also describe WESOM and its application in projects:

Krüger C., Doré L., Janßen T., Saurat M., Nebel A., Viebahn P. (2025). Providing the transport sector in Europe with fossil free energy - a model-based analysis under consideration of the MENA region. *Front. Energy Res.* 13:1524907. doi: 10.3389/fenrg.2025.1524907

Saurat, M., Doré, L., Janßen, T., Kiefer, S., Krüger, C., Nebel, A. (2022). Beschreibung des Energieversorgungsmodells WISEE-ESM-I. MENA-Fuels: Teilbericht 4 des Wuppertal Instituts an das Bundesministerium für Wirtschaft und Klimaschutz (BMWK). Wuppertal, Stuttgart, Köln, Saarbrücken

Krüger, C., Doré, L. (2022). Nachfrageszenarien – Storylines und Herleitung der Entwicklung der Nachfrage nach Synfuels und Grundstoffen. MENA-Fuels: Teilbericht 5 des Wuppertal Instituts an das Bundesministerium für Wirtschaft und Klimaschutz (BMWK). Wuppertal, Stuttgart, Köln, Saarbrücken

Krüger, C., Doré, L., Janßen, T. (2022). Basisszenarien – Ergebnisse und Infrastrukturauswertung. MENA-Fuels: Teilbericht 6 des Wuppertal Instituts an das Bundesministerium für Wirtschaft und Klimaschutz (BMWK). Wuppertal, Stuttgart, Köln, Saarbrücken

Doré, L., Krüger, C., & Janßen, T. (2022). Weitere Szenarioanalysen: Berücksichtigung von Investitionsrisiken und Sensitivitäten der Basisszenarien. MENA-Fuels: Teilbericht 7 des Wuppertal Instituts an das Bundesministerium für Wirtschaft und Klimaschutz (BMWK). Wuppertal, Stuttgart, Köln, Saarbrücken