

District Energy Model (DEM): A Python framework for modelling renewable energy integration and flexibility at district scale.

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Summary

The transition to locally generated, decentralised, and renewable energy technologies is a promising pathway toward net-zero emissions and a decarbonised energy system. This transition requires systematic evaluation of potential future scenarios for technology adoption across multiple spatial scales. Computational energy system models are used for this purpose. The *District Energy Model (DEM)* is a Python-based multi-energy system model designed to simulate scenarios from the neighbourhood to the regional scale, with a focus on the integration of decentralised renewable energy technologies such as solar, wind, and biomass. DEM can be used to execute simulation and optimisation studies at hourly resolution using a snapshot-year methodology. It is released as an open-source Python library on [PyPi](#). The model can be launched via a command-line interface, not requiring any Python programming knowledge. Alternatively, it can be accessed programmatically through Python. DEM requires two types of input: *configuration files* and *data files*. *Configuration files* specify the simulation settings (e.g., included buildings, temporal scope, output variables) and define the energy system configuration (e.g., scenarios, technologies, selected year). These configuration files are provided in YAML format ([Ben-Kiki et al., 2009](#)). Configuration parameters may also be passed directly to DEM in Python. *Data files* contain model data such as energy demand profiles, generation potentials, and ambient conditions. They are provided in Apache Feather format ([Apache Software Foundation, 2025](#)). For selected regions, these data files have been pre-compiled from public datasets and made available in a public repository, providing a fully parameterised model without requiring users to source or preprocess data. For example, data for a full parametrisation of DEM is available for all municipalities in Switzerland.

DEM's functionality is described in the project's [documentation](#), which includes step-by-step instructions, detailed descriptions of modelling approaches and methods, and links to related publications and research.

Statement of need

Several countries have defined national net-zero emission targets ([IPCC, 2023](#)). Switzerland, for example, aims to reach net-zero by 2050 ([The Federal Council, 2025](#)). Achieving such targets generally requires a structural shift from large, centralised generation to decentralised renewable resources, including solar, wind, and biomass ([Trutnevyte et al., 2024](#); [Van Liedekerke et al., 2025](#)). To support energy system planning and policy design, scenario evaluation must be carried out at local scales such as districts, municipalities, cities, or similarly sized regions. This includes analysing system-integrated deployment of renewable energy generation, conversion,

42 and storage technologies, assessing alternative demand trajectories, and identifying solutions
43 optimised for specific objectives such as cost, emissions, or security of supply.

44 DEM provides these functions with a specific focus on the use of local renewable energy
45 resources and the integration of decentralised technologies within local system boundaries.
46 Multiple energy system and demand scenarios can be defined, simulated, and compared.
47 Increased penetration of variable, distributed resources raises the relevance of supply- and
48 demand-side flexibility (Golmohamadi et al., 2024; Kachirayil et al., 2022). DEM models
49 several flexibility options, including flexible electric vehicle charging, thermal and electrical
50 storage, photovoltaic curtailment, and sector-coupling.

51 Existing multi-energy system models have been applied extensively in case studies of local
52 energy scenarios, but they typically target a single location. Each new application demands
53 re-parametrisation and new data collection, including demand profiles, cost estimates, and
54 technology characteristics. Data acquisition and preparation dominate the modelling workload
55 in such studies. DEM removes this burden for selected regions by providing pre-compiled and
56 pre-processed datasets assembled from public sources. Simulation and optimisation studies can
57 therefore be executed with minimal configuration (e.g., selecting the buildings to include) while
58 maintaining full flexibility to replace any pre-configured dataset with user-defined data when
59 required. For regions not included in the provided dataset, users can construct the necessary
60 data using the specifications provided in the documentation. DEM's input data architecture
61 allows datasets to be provided at a large regional scale (e.g., an entire country) that can then
62 be used to run simulations on any spatial subset of that data, such as individual municipalities
63 or districts.

64 Optimisation is optional in DEM. Many scenario questions, such as assessing the impact
65 of a specific technology, do not require optimisation because the system configuration is
66 fixed, the technology capacities are predetermined, or the aim is to examine feasibility, energy
67 balances, or system interactions rather than to identify an optimal design. Simulation is also
68 appropriate when the objective is to reproduce prescribed operating behaviour, when data
69 are insufficient to support a reliable optimisation formulation, or when the computational
70 burden of optimisation is unjustified for large scenario ensembles. In these cases, DEM runs
71 simulations without invoking the optimisation module, yielding short computation times and
72 direct results. This distinguishes DEM from optimisation-centric energy system models that
73 rely exclusively on optimisation and therefore cannot execute non-optimised scenario analyses
74 with fixed configurations or purely exploratory simulations.

75 Initially developed within the framework of a research project, DEM is designed for a di-
76 verse target audience extending from academia and research projects to decision-makers in
77 municipalities, energy utilities, and the industrial sector.

78 Modelling approach

79 DEM simulates energy flows within a defined district using a hybrid bottom-up and top-down
80 modelling approach. A “district” can represent any spatial scale, from a small group of buildings
81 to an entire municipality or city. Building-level attributes are modelled individually (e.g., type,
82 location, size, age, heat and electricity demand, heating system, and on-site solar potential).
83 Other parameters are defined at district scale, including wind and biomass resources, ambient
84 conditions, and mobility demand. Each simulation is constructed from three elements: a set of
85 available resources (e.g., wind, solar, biomass, hydro), a set of technologies for generation,
86 conversion, and storage, and a set of demand profiles for heat, electricity, and mobility. These
87 elements interact through defined flows of resources and energy carriers such as electricity
88 and heat. An example system layout is shown in Figure 1. DEM imposes no fixed limit on
89 the number of buildings included, allowing customised definitions of district boundaries and
90 building selections.

The workflow consists of: (1) input-data collection; (2) model parametrisation and configuration; (3) scenario generation; (4a) simulation; (4b) optimisation (optional); (5) output generation.

The optimisation module in DEM is implemented using the Calliope framework (Pfenninger & Pickering, 2018), which is based on the Pyomo optimisation programming environment (Hart et al., 2011).

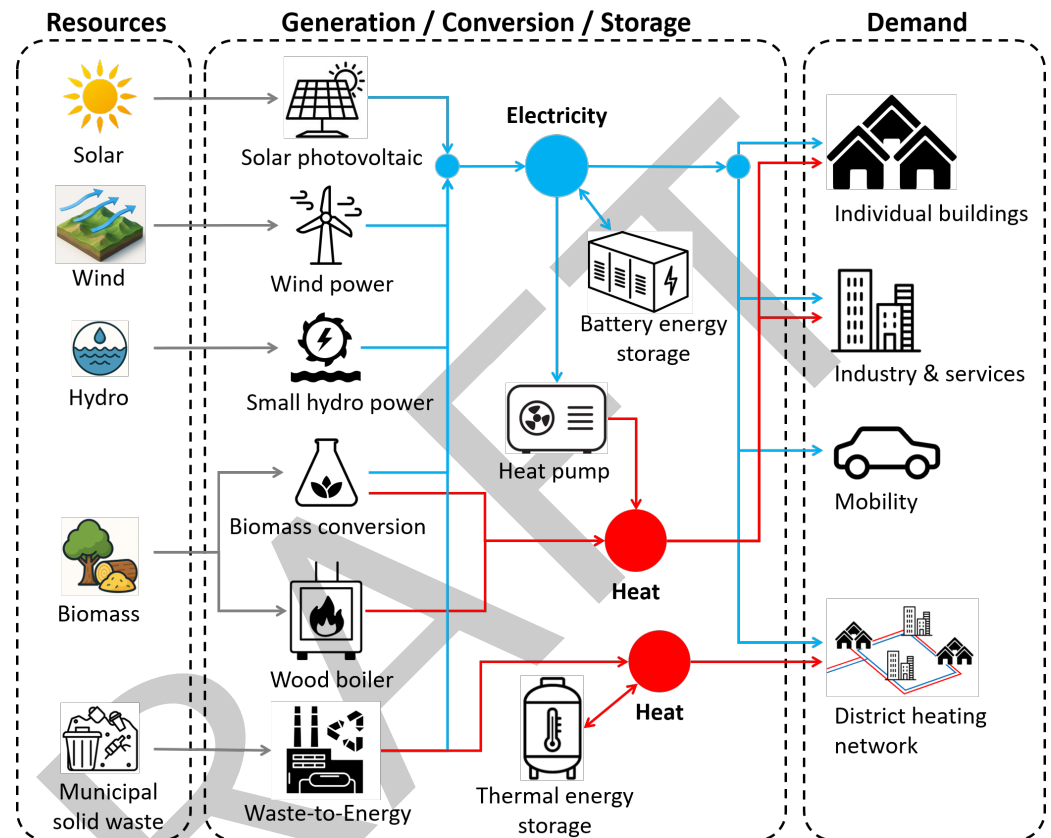


Figure 1: Schematic of an exemplary district energy system showing resources, generation, conversion, and storage technologies, and associated heat, electricity, and mobility demands. DEM supports many more technologies and scenarios than those illustrated here, as detailed in the [documentation](#).

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