**Overview**

This project centers on the development of deeco (dynamic energy, emissions, and cost optimization) – a versatile UNIX/Linux-based modeling environment capable of capturing many of the subtleties of distributed energy resources (DER). DER are, by definition, sensitive to:

- their placement within the system – a structural issue
- the way in which the system is managed – an operational issue

Moreover, the collective benefits of multiple DER tend not to be the sum of their stand-alone contributions. With reference to a specific public interest outcome, DER interactions may be either (Bruckner et al. 1997):

- synergetic or counteractive

deeco is based on an intertemporal process/flow model and employs optimization routines to identify least-cost operation. The underlying design draws heavily on operations research and engineering thermodynamics. deeco is normally used to analyze sustainability motivations improvements to energy-services supply by comparison with the status quo.

**Examples of DER**

deeo has been used to evaluate the following types of DER, often in combination and sometimes under staged introduction (see website for more details):

- multi-product plant: natural gas-fuelled combined-cycle cogeneration with secondary-firing / stationary (phosphoric acid) fuel cells
- high-efficiency devices: gas-motor, electric, and absorption heat-pumps
- fuel-passive measures: retrofitted domestic insulation / controlled solar architecture in the form of switchable transparent insulation (STI)
- operational policy revision: use of unit commitment other than short-run marginal cost (SRMC) minimization
- behavior change: for instance, temporal load shift
- renewable sourcing: wind farms / standard and concentrating solar thermal collectors / photovoltaic panels
- dispersed storage: solar-supported thermal storage

**Model attributes**

<table>
<thead>
<tr>
<th>Entity-oriented</th>
<th>High-resolution</th>
<th>Engineering-rich</th>
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</thead>
<tbody>
<tr>
<td>+ technologies: hardware, connectivity, unit commitment protocols</td>
<td>+ hardware connectivity (topology): at any appropriate level of resolution</td>
<td>+ minimum cost unit commitment: using LP optimization routines and/or secondary heuristics</td>
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<tr>
<td>+ context: environmental zones, commercial setting</td>
<td>+ temporal disaggregation: the default time-step is hourly</td>
<td>+ context-dependent performance: operational context is used to finalize plant efficiency and capacity relationships at each time-step</td>
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<td>+ actors: households, firms, institutions</td>
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<td>+ energy quality: explicitly supported, for instance, heat transport temperatures can be determined by control system proxy</td>
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<tr>
<td>+ energy-service supply obligations: preferably expressed as an intensity, for instance, indoor temperature or lux level</td>
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**Software engineering**

The model attributes shown above lend themselves to object-oriented programming. The core of deeco comprises 20 000 lines of C++. Perl scripting is used for the pre- and post-processing of data and Matlab is used for visualization.

**Public interest**

Suitably placed and managed DER can contribute to public interest goals such as decreased CO2 release and reduced fossil fuel dependence. deeco is designed to support public energy policy formation, particularly where (Morrison and Bruckner 2002):

- bundled policy measures are involved – policy integration – and
- outcomes need to be evaluated in terms of extra financial burden – additioality

**Modeling co-generation**

The following diagram shows the operational state of a utility-owned co-generation plant simulated under least financial cost operation.

**Supported technologies**

In addition to the examples listed, the technology library also contains: conventional furnaces and boilers, conversion thermal power plant, hybrid solar thermal power plant, steam rails, back-pressure steam turbines, gas-turbines, reciprocating engine co-generation plant, condensing boilers, heat reclaim heat-exchangers, short and long-range district heating grids, and (experimental) superconducting power storage.

**Work in progress**

deeo is currently being extended to support:

- MILP optimization – to enable shut-down mode unit commitment, for instance
- price discovery – which mimics actual rather than ideal markets
- multi-actor dynamics – including bounded rationality and coalition formation

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**Selected publications**


