SHORT DESCRIPTION

Optimal Dispatch Model (ODM)

LCU developed a model of the Ukrainian electricity system (Optimal Dispatch Model, ODM) that enables analysing different development scenarios of the electricity system, e.g. the impact of integrating additional capacities of RES into the grid. The main purpose of the model is to support Ukrainian policy makers in evaluating potential policy scenarios and make thus well-based decisions.

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Low Carbon Ukraine

Implemented by Berlin Economics

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Overview

We developed a model of the Ukrainian electricity system that enables analysing different development scenarios of the electricity system. Given assumptions on individual elements of the power system the model allows to analyse:

- Whether specific development pathways of the power system will be able to meet specific future demand profiles at any point in time
- What the cost of the power system for different development pathways are – this can allow comparing different pathways (e.g., retrofitting existing coal plants or replace existing coal plants by renewables)
- Where concrete bottlenecks are, and what could be low-cost options to fix them

These general capabilities can be used to answer a large number of concrete questions such as:

- Is it cheaper to retrofit a certain plant or replace it with another technology?
- Is it cheaper to locate wind turbines in most windy locations and add new lines to connect or curtail; or is it better to put them in well-connected places?
- What impact do specific rules of dispatch (curtailment, maintenance schedules, hydro power heuristics) have on cost and supply security?
- How much greenhouse gas is produced by the power sector?

Hence, the model allows to answer a number of strategic, political and regulatory questions:

- Example of a strategic question: Is a certain power plant park in line with the goals of the Energy Strategy?
- Example of a political question: Can Ukraine's electricity system accommodate the decommissioning of old coal capacities?
- Example of a regulatory question: What is the cost of curtailment?

The model analyses the cost-optimal dispatch of the Ukrainian electricity system for every hour of the year to establish which plant types/transmission capacities should be used in which region of the country. This then allows to identify bottlenecks – insufficient generation or transmission capacities – and calculate the fuel cost and emissions of the system. A sensible timeframe of analysis is five to forty years in the future (i.e., it mainly deals with investment/divestment questions for existing technologies).

To illustrate the scope of our model we situate it in a range of potential models:

INCREASING AGGREGATION LEVEL & TIME

Highly detailed electricity system model

- used for detailed grid planning and dispatch
- focus on short term
- accounts for specificities of AC (e.g., reactive power) and includes distribution grid

▸ potential user: DSO/TSO

Our model

- used for strategic grid and power system planning
- identification of major bottlenecks
- 5-40 years time horizon
- simplification of the electricity system (DC-approximation) and focus on transmission grid

▸ potential user: TSO/Ministry/SAEE

Integrated macro-economic energy system model

- used for long term energy system planning
- focus on whole energy system (not only power) and sectoral interactions
- aggregation of capacities and grids

▸ potential user: science, policy makers
e.g.: Times-Ukraine

Specifics of the Optimal Dispatch Model

Day-ahead dispatch optimality: The model optimizes the dispatch in a day-ahead perspective, defining stepwise the generation of installed capacities for the following hours depending on demand and weather conditions.

Time frame: The model enables analysis of different time frames, such as days, weeks, month or a whole year.

Time resolution: The time resolution is on hourly basis.

Technologies: The model considers conventional power capacities such as nuclear (NPP), different types of thermal power plants (TPP), furthermore renewable sources (wind, solar, biogas and hydro) as well as storage capacities such as batteries and pump hydro capacities.

Technological specifics: For each electricity generation type, (different) technological parameters can be considered, such as installed capacity, capacity factors, ramping constraints unit efficiency , unit fuel, fuel costs and/or minimal run-times.

Generation costs: Generation costs are marginal prices for each technology. Start-up costs for thermal power plants can be considered too.

Regions: The model considers different regions, representing either TSO-regions (here described as nodes) or countries that are connected via transmission lines.

Transmission: Each two nodes are connected by no more than one transmission line. The maximum capacity of the transmission between two nodes is considered, and the balance rule at nodes. Kirchhoff laws are considered.

Import: In case of no explicit description of neighbour countries, import and export of electricity are described as a generation types for those regions that are connected to foreign countries. Different, region depending prices can be considered. Furthermore, foreign countries can be described as single regions with specific generation capacities.

Power plants and units: At each node (in each region) the generation of one specific generation type is considered. For considering different unit types (e.g. differing in sizes, associated marginal costs and ramping constraints), different units can be defined.

Unit commitment: Thermal Power Plans are described on unit level and standard unit commitment, as discussed in the literature is considered.

Demand: Fluctuating demand is defined by using the hourly electricity demand for each region.

RES: Power generation from fluctuating renewables (wind and solar) are constrained by weather dependent capacity factors, that are considered for each of the regions.

Reserves and flexibility: Reserves and flexibility (representing intra-day trade, not depicted in the day-ahead view) can be considered either by fix reserve requirements or based on uncertainties resulting from RES and demand fluctuations. Regional reserve requirements -- e.g. N-1 criteria -- can be considered in case of analysing different countries.

Curtailment: The model allows for considering curtailment of RES.

Implementation: The model is implemented in Pyomo, a Python-based, open-source optimization modelling http://www.pyomo.org. Pyomo enables the usage of different open-source solvers (e.g. CBC, GLPK) as well as commercial solvers, such as MOSEK, GUROBI, CPLEX and further.

Structure of inputs and outputs

Input

- installed capacitities for each electricity generation type
- regional wind and solar capacity factors trajectories
- regional demand trajectories
- marginal costs for each electricity generation type
- status of TPP units
- initial stocks of pump storage, batteries and big hydro reservoirs
- technological parameter

→ 24 hour dispatch optimization →

Output

- regional electricity generation of each unit/power plant
- curtailment of wind and solar
- aggregated and cumulated generation costs
- status of TTP units
- end stocks of pump storage, batteries and big hydro reservoirs

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Low Carbon Ukraine is a project with the mission to continuously support the Ukrainian government with demand-driven analysis and policy proposals to promote the transition towards a low-carbon economy.

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All results of the project are available online on www.LowCarbonUkraine.com.

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