

GHG and Pollution Modeling in PLEXOS®



Leading the field in
Energy Market Modelling

Sai Koppolu and Dr. Randell Johnson

Many studies require cost and benefits analysis of pollutants and GHG's where this white paper we discuss emission modeling and analysis of systems.

Generation of electricity by fossil-fired plant produces a range of combustion by-products such as NOx (NO and NO2), SOx (SO and SO2) and CO2:

- A database may include production details, constraints, and taxes on any number of emissions.
- Emissions can be produced, absorbed (scrubbed), constrained, and penalized across all or any subset of generators and/or fuels.
- Constraints can be placed on the total of any emission and/or on a subset of producers across any time period including multi-annual constraints.
- There is no limit the number of emission limits modelled.
- Emission grandfather rights can be modelled.

Emission Rates

In PLEXOS, the user can create any kind of Emission (eg COx, NOx, SOx, Solid Particle, etc) using its specialized Emission class. Emissions are associated with Generation and Fuel Offtake by defining the following properties:

- Emission Generators [Production Rate] property defines the functional relationship between megawatt generation and emissions.
- Emission Fuels [Production Rate] property defines the functional relationship between fuel usage and emissions.

Abatement

The abatement of emissions is modelled either:

- As a simple proportion of emissions via the Emission Generators Removal Rate property combined with Removal Cost; or
- Using Abatement objects

Abatement objects provide detailed modelling of the physical and cost aspects of abatement technologies as well allowing the simulator to optimize the choice of technologies employed from a set of defined alternatives.

Incremental Cost

The incremental cost of emissions on Generation is a function of the Shadow Price and defined production rates net of any removal rate or other scaling. This incremental cost is reported as Generators Incremental Cost and forms part of the Short-Run Marginal Cost (SRMC).

Constraints

More complex emission constraints are created using Constraint objects. The emission constraints are fully integrated into the mathematical programming problem, the dispatch and pricing outcome will reflect the economic impact of the constraints. This means that, when an emission constraint is binding, lower emitting plant will be favored over high emission plant, thus the merit-order of generators will change. However generators in many schemes that implement the Kyoto protocol incumbent generating companies are given grandfather rights to emit. This allocation of rights can be modelled using the Company Emissions property. These allocations pass back to the company and affect Net Profit. When running models this will result in generator bidding behavior reflective of the net position with respect to emissions e.g. a high emitter may retain its place in the merit order if its allocation of emission right is high enough.

Emission Taxes/Prices

In addition to or instead of modelling physical emission limits, emission taxes/prices can be modelled either by:

- Setting the emission Shadow Price directly; or
- Defining a soft constraint i.e. one with one or more bands of penalty price.

Price is treated as the 'accounting price' for emissions. This is the price used to compute cost assigned to generators for their emissions, but it is distinct from the Shadow Price which is the 'dispatch price' meaning that this is the price used to adjust generator offer prices to account for emissions.

Costs and Benefits

It is possible with detailed modeling of emissions and emission constraints and pricing to then determine costs and benefits. Costs could be short run costs of emission production at a penalty price or capital costs of removing emissions or different capacity expansion decisions to minimize emissions. Benefits can be emissions reductions as well as cleaner environment and avoidance of short run costs of emissions productions and or credits for not producing emissions. PLEXOS® has many metrics such as emission intensity for a power sector both before and after expansion cases as well as financial, economic, and production metrics for emissions. PLEXOS® can minimize NPV of a system capacity expansion scenario with emission reduction targets. A base line emission target scenario is easily created. As well PLEXOS® can minimize emissions during short run production cost simulations as well.