Comments on the specs03.pdf, version of Sep. 15

Marek

SEPTEMBER 15, 2021

Note: This draft is rather an illustration how to write the SMS than an advanced SMS draft. The purpose of this draft is to provide a background for discussion on how to proceed.

Editorial

Please ALWAYS place your name and the current date on ANY document.

1 Symbolic model specification (SMS)

The SMS documents all model entities (indexing structure, variables, parameters, relations). This draft is an incomplete SMS aimed at illustrating the SMS structure and basic elements.

1.1 The model purpose

The model aims at supporting analysis of the relations between the decisions and consequences of their implementation. The latter is represented by the outcome variables.

1.2 Indexing structure

1.2.1 Intro to indexing structure

The SMS uses the Structured Modeling (SM) concepts; in particular the compound entities. For example, a compound variable $\mathbf{x}$ actually represents a set of variables $x_{ij}, i \in I,\ j \in J$, where i and j stand for indices, and I and J are the sets of values of the corresponding indices. To illustrate this concept, let $\mathbf{x}$ be flows between i-th warehouse and j-th store. Then the set I of warehouses can be defined as $I = \{city1, city2, \ldots\}$. Similarly, the set J of shops can be defined as $J = \{loc1, loc2, \ldots\}$.

Thus, the indexing structure is composed of:

- symbols of indices (typically a lower-case letter), and
- symbols of sets (typically, the corresponding upper-case letter).

The examples of the index-sets below are for illustration only. The actual members of these sets are defined by the model parameters.

1.2.2 Indexing structure of the model

The model uses the following indices and the corresponding sets:

- $t \in T$ technologies, $T = \{\mathrm{OTL}, \mathrm{BTL}, \mathrm{PTL}, \ldots\}$, $T_f \subset T$ technologies directly producing the final commodities
- $y \in Y$ 5-year period id, $Y = \{2020, 2025, \ldots 2050\}$,

- Using the convention for periods defined by the sequence (2020, ..., 2050) causes complicated definitions of the corresponding relations (see below). Therefore I would consider to use another index for periods, say $p \in P$, where $P = \{-\tau, -tau+1, \ldots, 1, 2, \ldots, 7\}$, where non-positive values correspond to historical (before the planning period) periods. This will allow easy definitions and use of historical and current new capacities. The correspondence between Y and P can be defined by a simple mapping. In the formulae below I use the $p \in P$ instead of $y \in Y$.[1] v $\in V$ vintage (construction time) period id, $V = H \cup \{2020, 2025, \ldots 2050\}$, where H is the set of historical (previous) periods for which the corresponding new capacities are defined by the data,
- $c \in C$ commodity, $C = \{\mathrm{oil}, \mathrm{gasoline}, \mathrm{coal}, \mathrm{crude-oil}, \ldots\}$, $C_f \subset C$: final commodities,
- ...

  Notes for Jinyang:
- We probably need to define subsets of C, e.g., for dealing with final commodities.
- I strongly recommend to refrain from using v^y (or any other symbol defined by a letter with subscript/superscript) for an index. Therefore, I propose to use v for the vintage year index.

1.3 Variables

Although all variables are treated equally within the model, we divide the set of all model variables into categories corresponding to the roles; this helps for structuring the model presentation.

1.3.1 Decision variables

Decision-makers control the modeled system by decision (control) variables:
- $ncap_{tv}, t \in T, v \in V$: new production capacity of t-th technology, made available at the beginning of p-th period,
- $act_{tvp}, t \in T, v \in V, p \in P$: activity level of t-th technology, using in period p the new capacity provided in period v.

  Editorial notes:
- We use[2] a short notation, i.e., x_{ijk} instead of $x_{i,j,k}$.
- Further on we skip the obvious explanations of the meaning of the indices.

1.3.2 Outcome variables

Outcome variables are used for evaluation of the consequences of implementation of the decisions; therefore at least one of them is used as the optimization objective.

In the model prototype only two outcomes (both used as criteria in multiple-criteria model analysis) are defined:
- $cost$: the total cost of the system over the planning period, and
- $CO2$: the total CO2 emission caused by the system.

[1] Let's discuss this issues.

[2] JZ: it is up to you, which of these two notations you want to use. For the compactness I usually use the short one.

1.3.3 State variables

The variables defining the state of the system:
- cap_{tp}: production capacity. *Note: this may not be needed, let's consider the relations defined in Section 1.5 and discuss.*
- ...

1.3.4 Auxiliary variables

All other variables used in the SMS:
- ...

1.4 Parameters

The following model parameters are used in the model relations specified in in Section 1.5:
- values of indices (members of sets) specified in Section 1.2.2,
- τ_t: lifetime (number of periods) of the new capacity,
- $d_{cp}, c \in C_f$: demand for final commodities defined by $C_f \subset C$
- a_{tvc}: amount of product from the unit of the corresponding activity

1.5 Relations

The values of the model variables conform to the following model relations.
- The sum of activities act_{tvp} shall shall result in producing the required amounts of the final commodities:

$$\sum_{t \in T_f} \sum_{v \in V_{tp}} a_{tvc} \cdot act_{tvp} \geq d_{cp} \quad c \in C_f, p \in P. \tag{1}$$

  where $V_{tp} \subset V$ is defined by:

$$V_{tp} = \{p - tau_t, p - tau_t + 1, \ldots, p\} \tag{2}$$

- The levels of activities cannot exceed the corresponding capacities:

$$act_{tvp} \leq ncap_{tvp}, \quad t \in T, v \in V_p, p \in P. \tag{3}$$

  Note: The values new capacities $ncap_{tvp}$ within the planning period ($v \in P$) are defined by the decision variables. However, for the non-positive values of V_{tp} (i.e., historical investments) are defined by the model parameters.

Copy of comments of Sep. 1, 2021

In order to assure consistency between the problem formulation and the corresponding model, I would consider replacement of the obviously incorrect inequality (9) by:

1. Equation defining the amounts of each of the fuels as a function of the activities of the applied technologies:

$$\sum_{i \in I} a_{ji} \cdot ACT_i^t = x_j^t, \quad j \in J,\ t \in T \tag{4}$$

   where:
   - j denotes fuel type, $J = \{gasoline, diesel\}$,
   - a_{ji} relates the amount of j-th fuel produced by the unit of i-th ACT,
   - x_j^t stands for the amount of j-th fuel produced jointly by all considered technologies at period t.

2. Adding the supply-demand constraint, specification of which depends on the chosen definition of demand. Here we can consider one of the following two options:
   1. If the demand is given for each fuel type, i.e., as d_j^t, then:

$$x_j^t \geq d_j^t, \quad j \in J,\ t \in T. \tag{5}$$

   2. If the demand is given for a linear aggregation of d_j^t, e.g., by coefficients α_j conforming to:

$$0 \leq \alpha_j \leq 1,\ \forall j \in J; \quad \sum_{j \in J} \alpha_j = 1. \tag{6}$$

      Thus, the demand is given for a *virtual* (i.e., not actually existing) fuel:

$$d^t = \sum_{j \in J} \alpha_j \cdot d_j^t, \quad t \in T. \tag{7}$$

      In such a case instead constraint (5) one shall add constraint:

$$\sum_{j \in J} \alpha_j \cdot x_j^t \geq d^t, \quad t \in T. \tag{8}$$