



Summary of recent TIMES enhancements (v2.8.0 – v3.0.4)

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ETSAP

ENERGY TECHNOLOGY SYSTEMS ANALYSIS PROGRAM

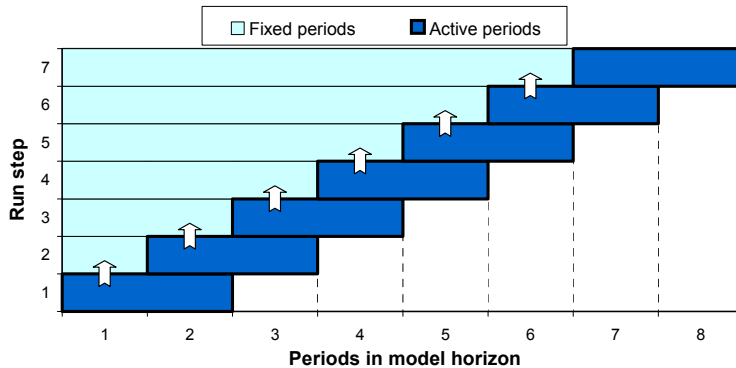


Fixing first periods to previous solution

- ▶ Can be very useful for freezing the model solution to the Baseline scenario for the nearest future (or at least until present)
- ▶ Requires that the Baseline solution has been saved to a GDX file
- ▶ Freezing is activated by using two GAMS control variables:
 - \$SET FIXBOH <last_year_to_freeze>
 - \$SET LPOINT <run_name>
- ▶ The periods can also be frozen differently by region
 - ▶ Parameter REG_FIXT(reg) defines the last_year_to_freeze
- ▶ The feature can now be also used with stochastic mode and sensitivity / tradeoff analysis
- ▶ Can even be used recursively, for a manual *stepped solution*

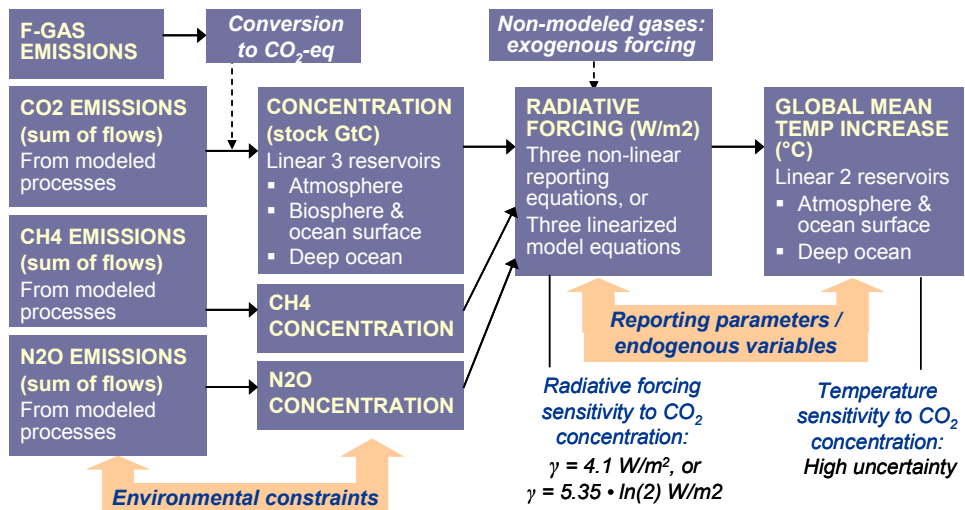
Time-stepped TIMES

- ▶ Standard TIMES is *clairvoyant*, i.e. has perfect foresight
- ▶ Time-stepped TIMES *myopic*, i.e. has limited foresight
 - ▮ Model is solved in a recursive-dynamic fashion
 - ▮ Activated by control variable \$SET TIMESTEP <step_length>
 - ▮ Additional parameter G_OVERLAP defines the step overlap



3

Enhancements in the TIMES Climate Module



4

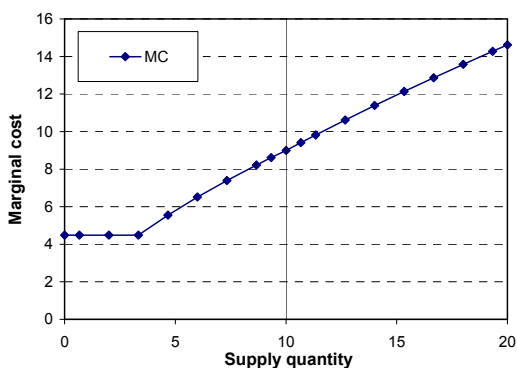
Extending the climate equations beyond EOH

- ▶ Motivation: Climate change has considerable time lags:
 - ┆ For example, temperature will continue to rise even long after strong emission cuts
 - ▶ It can be useful to be able to set climate targets beyond EOH
- ▶ TIMES v3.0.0 and above allow using the climate equations over any user-defined time-span beyond EOH:
 - ▶ Requires setting EOTIME in the run file (or VEDA SysSettings)
 - ▶ Setting CM_CONST('EXT-EOH') defines an extrapolation point for the global emissions (e.g. 2150, or 0 for the EOH)
 - ▶ CM_MAXC bounds on emissions beyond that year will be considered emission projections (e.g. zero emissions in 2200)
 - ▶ CM_MAXC bounds on temperature, forcing and concentration can be defined for any years beyond EOH

5

Elastic supply cost curves

- ▶ Elastic supply costs around a base quantity, for any commodity
- ▶ Could be useful by providing an automatic generation of supply cost curves for imported commodities:
 - ▶ Base price and quantity automatically transferred from Baseline
- ▶ Implemented as an extension to the Damage Cost facility of TIMES



6

Enhanced cumulative constraints

- ▶ The following cumulative attributes are now supported:
 - ▶ COM_CUMNET(reg,y1,y2,com,lim) (old)
 - ▶ COM_CUMPRD(reg,y1,y2,com,lim) (old)
 - ▶ ACT_CUM(reg,prc,y1,y2,lim) (new)
 - ▶ FLO_CUM(reg,prc,com,y1,y2,lim) (new)
 - ▶ UC_CUMACT(uc_n,reg,prc,y1,y2) (new)
 - ▶ UC_CUMFLO(uc_n,reg,prc,com,y1,y2) (new)
 - ▶ UC_CUMCOM(uc_n,reg,type,com,y1,y2) (new)
- ▶ The 'N' bound type can be used for defining a horizon-dependent MULTI multiplier index for the cumulative bound
- ▶ New UC_TIME attribute can be used for defining horizon-dependent RHS constants for cumulative UC constraints
- Support for using cumulative constraints under variable horizon lengths and Time-stepped mode greatly improved!

7

Simplified dynamic process bound equations

- ▶ Simple dynamic constraints for processes are frequently needed:
 - ▶ Growth constraints for capacity / activity
 - ▶ Decay constraints for capacity / activity
 - ▶ Limits for new capacity installation between periods
- ▶ Such constraints can be defined by the UC facility, but that may become cumbersome for a large number of similar constraints
- ▶ TIMES v3.04 and above will support defining simple process-wise dynamic constraints in an easier way, without introducing UC_N names for each constraint
 - ▶ The powerful process filter and rule-based constraint facilities of VEDA-FE and ANSWER can be used for bulk creation of dynamic process constraints
- ▶ Employs UC_CAP, UC_ACT and UC_NCAP, but without RHSxxx

8

Miscellaneous small enhancements

- ▶ Increased flexibility in the inter-regional topology of IRE processes
- | The bounds of the Objective Function component variables can now be user-defined (e.g. making variable costs a “free” variable)
 - ▶ By UC_RHS / UC_RHSR with predefined UC_N names (OBJINV, OBJFIX, OBJVAR, OBJSAL)
- ▶ Capacity-related flows can now be referred to in UC constraints:
 - ▶ Normal UC_FLO(...) will include the cap-flows whenever UC_ATTR(reg,uc_n,side, 'FLO', 'CAPFLO') is also specified
- | New G_OFFTHD parameter for fine-tuning of process availability:
 - ▶ Affects the impact of *_OFF parameters at period boundaries
- ▶ Support for using the *Savage Minimax Criterion* in stochastic mode
- ▶ New uncertain attribute S_FLO_CUM is available under stochastic mode (uncertain equivalent of FLO_CUM)

9

Reporting enhancements

- ▶ VAR_FIN / VAR_FOUT reporting at COM_TS or ANNUAL level
- | Cplex Objective ranging information can be provided for VAR_NCAP variables (may take a lot of time in the solver)
- ▶ New reporting attributes:
 - ▶ Marginals and levels of cumulative process constraints
 - ▶ Marginals of inter-regional exchange equations
 - ▶ Marginals of dynamic process bound equations
 - ▶ New VAR_NCAPR attribute:
 - ▶ Benefit-Cost indicators for VAR_NCAP variables (optional)
 - ▶ Activate by control variable: \$SET BENCOST YES
 - ▶ Includes the costs, benefits, competitiveness gap and ratio
 - ▶ Includes the Cplex ranging information (if activated)
- ▶ ANSWER-TIMES reporting now supports stochastic mode

10

Issues with Storage

- ▶ Original TIMES formulation allows arbitrary by-pass flows through storage processes in the each timeslice / period
- ▶ This may cause problems for market-share constraints or other bounding constraints (especially through VAR_COMPRD)
- ▶ In **TIMES v3.0.4** the issue can be addressed in the following ways:
 1. Define the stored commodity only as an Output or Input (TOP)
 - ▶ Storage input and output flows will then appear either only on the production side or only on the consumption side of the commodity balance equations
 - ▶ Backwards compatibility by using both IN+OUT (or none)
 2. The output flow can be limited to the maximum amount that could be discharged from the storage, using FLO_SHAR:
 - ▶ FLO_SHAR(reg, y, prc, com, 'ACT', 'ANNUAL', 'UP')
- ▶ Additional issue related to peaking constraints needs to be resolved

11

TIMES Matrix Tools (Courtesy of IER)

- ▶ The **Matrix Tools** are a stand-alone set of utilities for analysing the primal and dual equations and solutions of TIMES models
- ▶ The tools can be used for producing comprehensive reports about:
 - ▶ the LP matrix coefficients, by constraint or variable
 - ▶ the primal and dual solution
 - ▶ combined solution attributes that can be used for analyzing the components of the dual constraints for primal variables
 - ▶ value flows and benefit / cost ratios for decision variables
- ▶ The Matrix Tools are thus the *ultimate tool* for full-blown solution analysis, including detailed value flows and benefit-cost indicators
- ▶ An excellent tool for pedagogical purposes
- ▶ Shortcomings: Large results database, no ranging information

12

Conclusions

- ▶ Practically all significant MARKAL features are available in TIMES
 - ▶ Some features nonetheless missing from TIMES, including:
Early retirement of technologies, Net emissions accounting, SAGE market share algorithm, and MGA
- ▶ The standard TIMES code appears to have reached a good level of stability and robustness

The latest TIMES version v3.0.4
will be publicly released by end of June

- ▶ A number of further enhancements been suggested, for example:
 - ▶ Report the levelised costs of technologies by vintage (or period?)
 - ▶ Incorporate full ranging information into TIMES results
- ▶ Advanced TIMES users are encouraged to implement useful new features and contribute them into the common ETSAP code base!