IFE, Kjeller (Norway), January 23-25, 2012

Demand elasticities in the partial equilibrium mode of TIMES

Kathleen Vaillancourt, GERAD, kathleen.vaillancourt@gerad.ca
Maurizio Gargiulo, E4SMA S.r.l., gargiulo.maurizio@gmail.com
GianCarlo TOSATO, IEA/ETSAP, gct@etsap.org

Contents

Maximisation of the total surplus

- The total surplus of an economy is the sum of the suppliers' and the consumers' surpluses.

  - *Supply curve*: in each step the commodity is produced by a set of technologies in a strictly linear fashion.

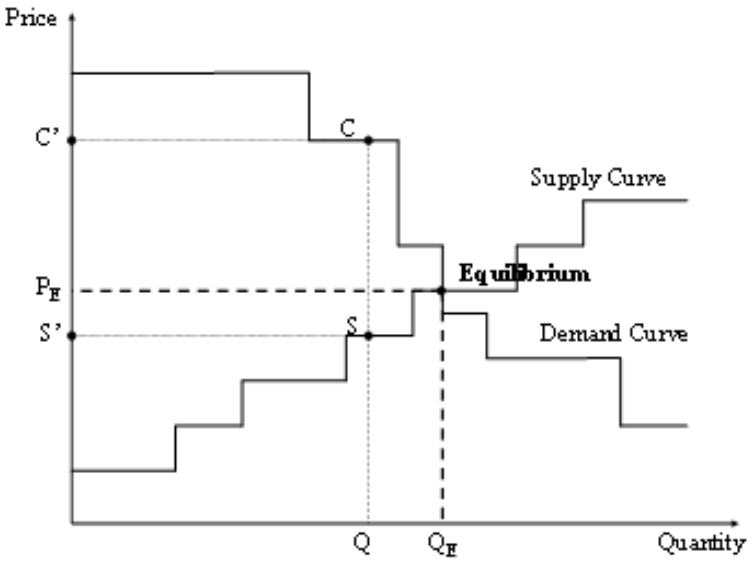
    Each change generates one step of the staircase with a value higher than the preceding step.

  - *Demand curve for energy carriers*: Implicitly constructed within TIMES, as a step-wise constant, decreasing function of the quantity demanded.

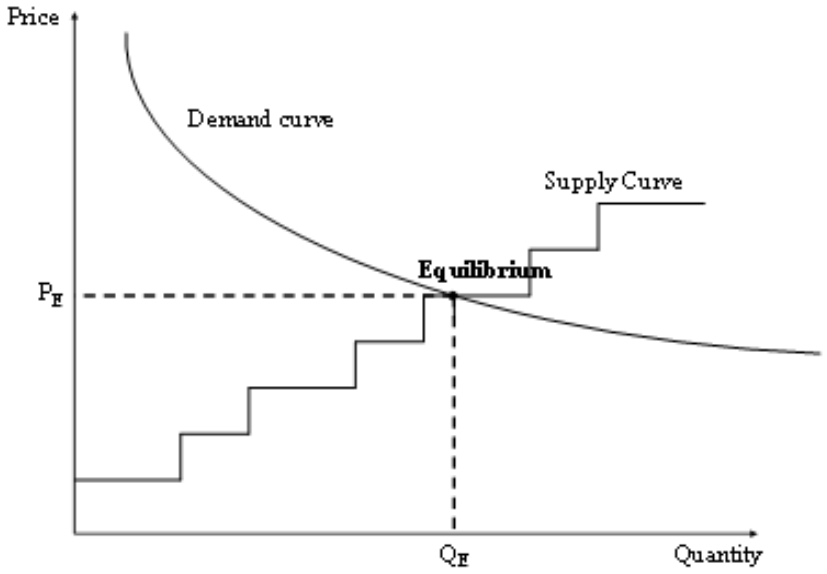
  - *Demand curve for energy services*: Defined by the user via the specification of the own-price elasticity of that demand.

Maximisation of the total surplus

- Equivalence Theorem: A supply/demand economic equilibrium (QE and PE) is reached when the sum of the producers and the consumers surpluses is max.



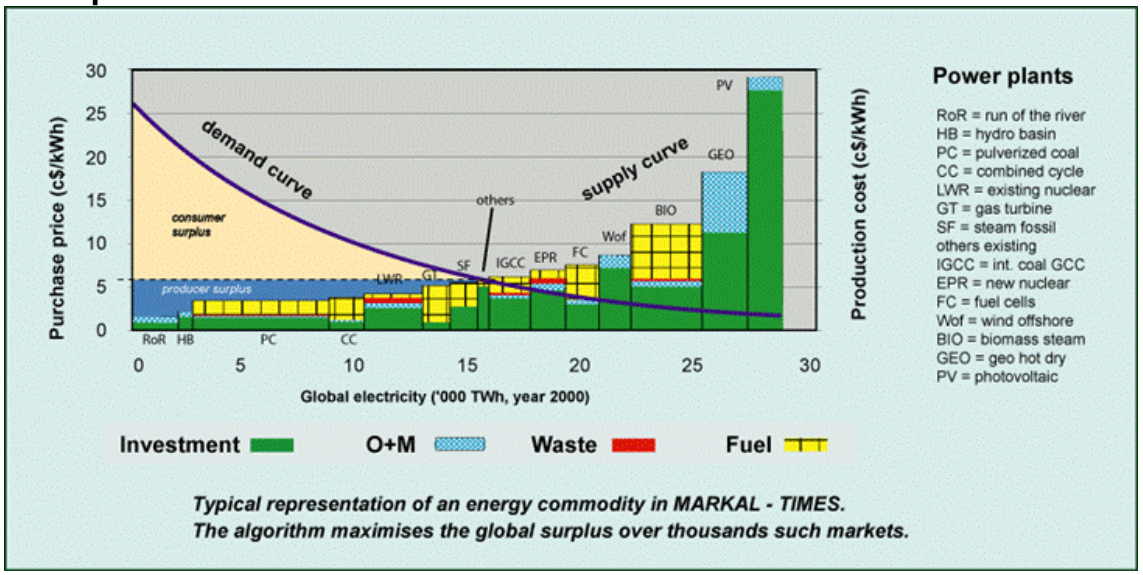
Equilibrium in the case of an energy form



Equilibrium in the case of an energy service

Maximisation of the total surplus

- TIMES computes a supply-demand equilibrium where both the supply options and the energy service demands are computed by the model.
- The equilibrium is driven by the user-defined specification of demand functions, which determine how each energy service demand varies as a function of the market price of that energy service.
- Each demand has constant own-price elasticity in a given time period, and that cross price elasticities are zero.
- The equilibrium thus corresponds to the maximization of the net total surplus.



Typical representation of an energy commodity in MARKAL - TIMES.
The algorithm maximises the global surplus over thousands such markets.

Maximisation of the total surplus

- The model is run in two modes:
  - **A reference case**: without constraint, leaving the model free to achieve that goal at least cost.
  - **Alternate scenarios**: with constraints to represent energy or climate policies (e.g. emission taxes, emission cap, minimum bound on electricity production from renewables such as portfolio standards, etc.), resulting in increases in the marginal values of at least some energy services (e.g. severe emission reductions may increase the price of road transportation).
- Demands self-adjust in reaction to changes (relative to the reference case) of their own price, and therefore the model goes beyond the optimization of the energy sector only (Contrary to traditional bottom-up models).
- The change in demands is considered as a good measure of the main feedback economic effect of energy system policies.

Defining Demand Functions - Theory

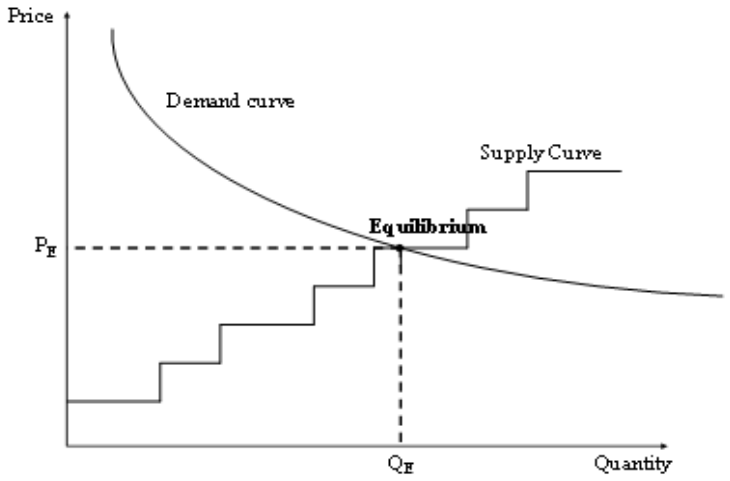
- The user explicitly defines the demand function by specifying its own price elasticity. Each energy service demand is assumed to have a constant own price elasticity function : $D/D_0 = (P/P_0)^E$

where :

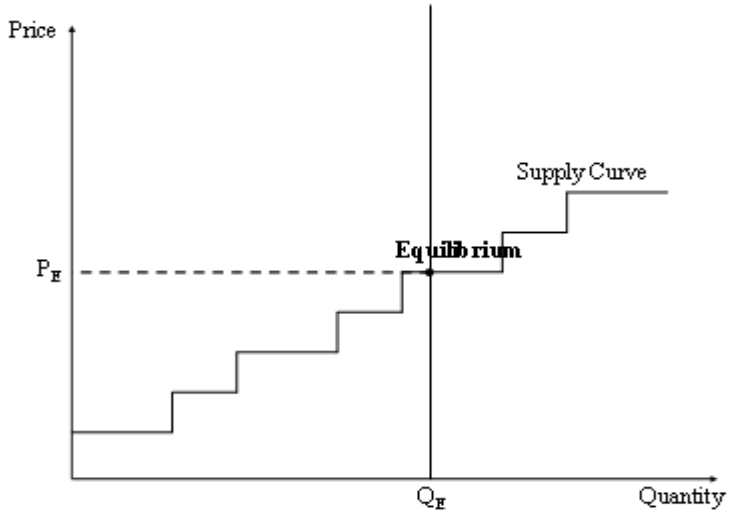
D_0 ,P_0 is a reference pair of demand and price values for that energy service over the forecast horizon, obtained by solving TIMES for a reference scenario:

D_0 is the demand projection, **P_0** is the shadow price of that energy service demand.

E is the (negative) own price elasticity of that energy service demand.



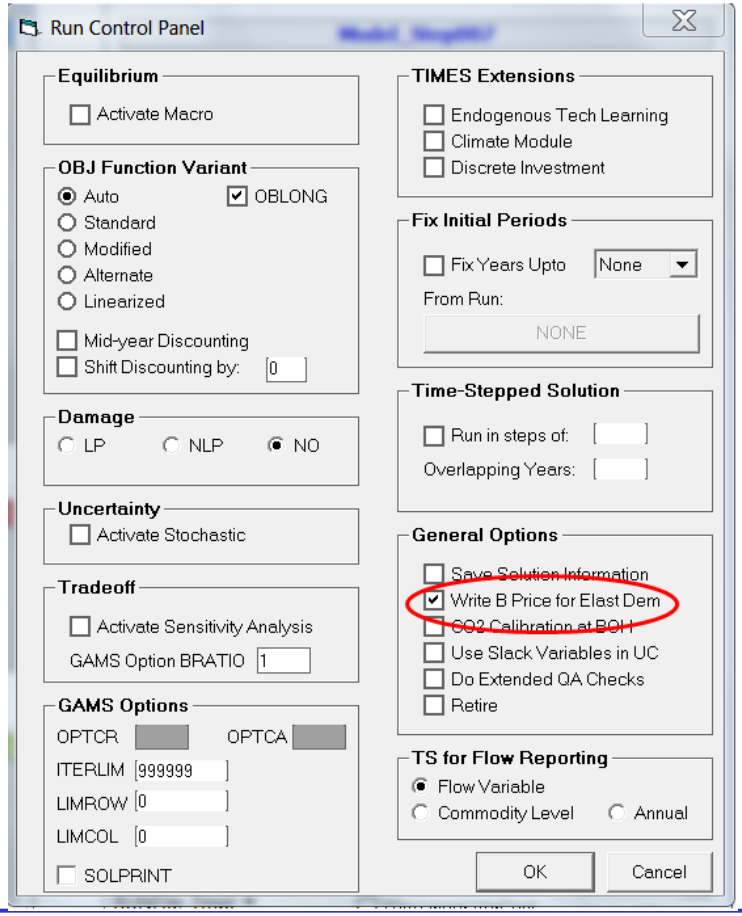
Equilibrium with elastic demands



Equilibrium with fixed demands

How to run the TIMES elastic demand in VEDA-FE

- **Solve the reference case**
  - Select the appropriate scenarios to include in the reference case (generally no constraint or tax on CO_2 emissions)
  - In the Run Control Panel, select the option “Write B Price for Elast Dem”



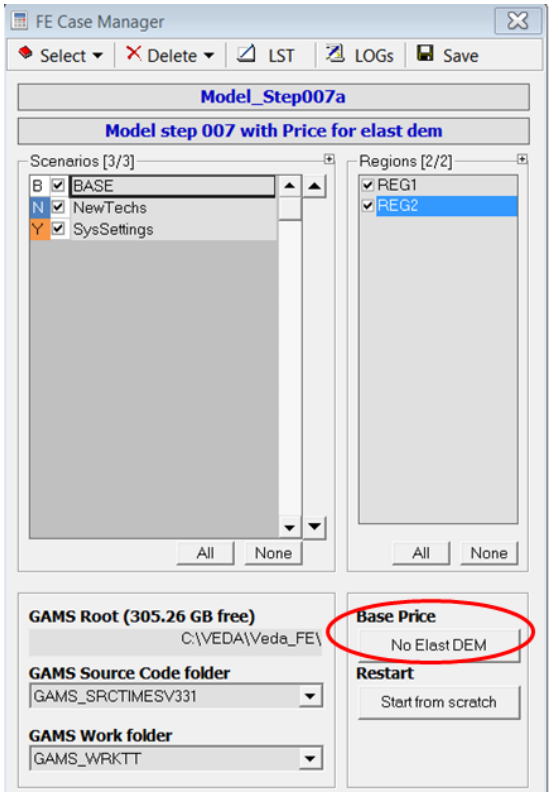
How to run the TIMES elastic demand in VEDA-FE

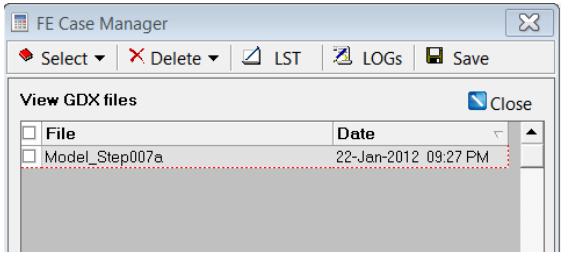
- **Build an alternative scenario including elasticity**
  - Including CO_2 emission constraint or tax, etc
  - To allow elastic demands add the following parameters
    - COM_ELAST: Elasticity of demand indicating how much the demand rises/falls in response to a unit change in the marginal cost of meeting a demand that is elastic. (e.g. -0.15 for LO and -0.05 for UP)
    - COM_VOC: Possible variation of demand in both directions when using the elastic demand formulation. (e.g. 0.2 for LO and 0.1 for UP)
    - COM_STEP: Number of steps to use for the approximation of change of producer/consumer surplus when using the elastic demand formulation. (e.g. 10)

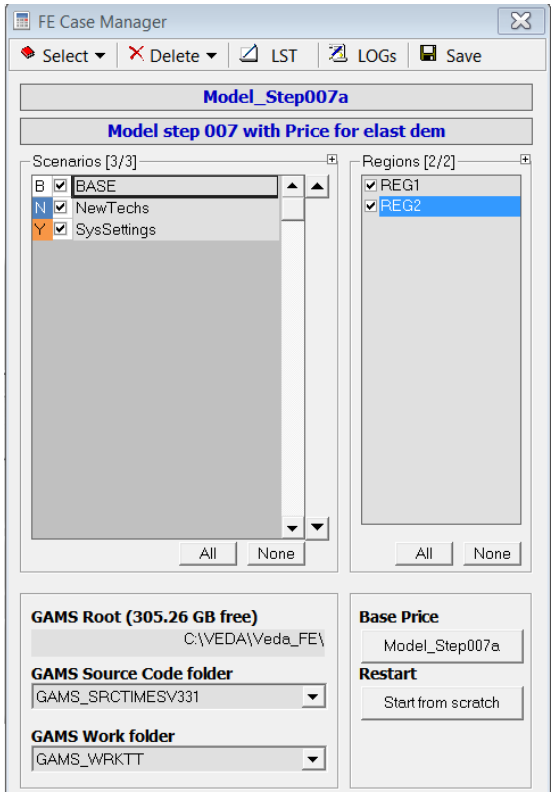
How to run the TIMES elastic demand in VEDA-FE

- **Solve the alternative scenarios**
  - Solve the alternative scenario with CO2 constraint of tax
  - Solve the alternative scenario with CO2 and elastic demand

    In the FE Case Manager, Basic Price:
    - At the beginning there is No Elast Dem
    - Then you will see the scenario name used to write the B price







How to run the TIMES elastic demand in VEDA-FE

- **Solve the alternative scenarios**
  - New run name and solve the model

- **Results analysis** (CO_2 emissions and demands)
  - Reference case
  - Alternative scenario with CO_2 constraint/tax
  - Alternative scenario with CO_2 constraint/tax and elastic demand