Modeling of Energy Security in TIMES (from PLANETS project)

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Defining an overall security index

• Two starting points:
  − Excessive reliance on a single (or a few) technology is risky: diversification is desirable
  − Each technology has a specific risk of failure attached to it

• The main idea is to select a technological mix that takes into account its cost, its diversification, and its overall risk
  − Cost is already well modeled in TIMES
  − Diversification (or concentration) measures exist in the literature but are very non linear ...
  − Specific risk measures of the technologies should also play a role
What is a Security index?

- The classical *market power* indicators are quadratic functions of the market shares (Herfindahl-Hirschman *concentration* index, used by market regulation authorities). The reciprocal of the same function gives the Simpson *diversity index* (used in ecology).

- An alternative diversity index is a logarithmic function of the shares (Shannon-Wiener Indicator).

- Combination of *risk index* and a concentration indicator will result in a *security index*.

- Linearize the risk indicator ??

Concentration measures

- Usual *concentration indexes* are non linear (sum of squares, logarithms).

  Minimize \( \{ \text{SUM}_i f_i(x)^2 \} \)

- Linear version:

  Minimize \( \{ \text{Max}_i f_i(x) \} \)

  has a similar but stronger diversification effect.
Linear security index for a multi-regional energy system (e.g. E.U)

\[ \text{Min } [C + \alpha \sum_r \text{Max}_p \{R(p) \cdot ACT(r,p)\}] \quad (1) \]

Where \( p \) is a process, \( r \) is a region

\( ACT(f,p) \) is the activity level of technology \( p \)

\( R(c) \) is the risk index of technology \( p \)

Our index includes a risk factor for each technology. Therefore, the new objective function is a hybrid between cost of entire system (to be minimized), concentration of technologies (to be minimized) weighed by risk of technologies (to be minimized)

Risk modelling: Two general properties

- **Anticipation**: methods that take risk into account before failures occur (via diversification, selection of less risky corridors, etc.)
  - Crucially important: early investments MUST be made while taken into accounts future risks. Examples: security indexes, robust programming, chance constrained programming.

- **Remediation**: methods that tell what to do when a failure occurs
  - Less important: remedial actions will be taken in future. Example: Stochastic Programming
Some implementation details

- Although the method is presented as a parameterized objective function, it may be implemented in a different way, available in TIMES via the new SENSIS option (Lettila, 2007)

For instance:
- Minimize Cost only  \( \gg \) obtain \( \text{OptCost} \)
- Minimize Risk only, subject to Cost \(< (1+a)*\text{OptCost} \gg \) obtain \( \text{OptRisk} \)
- Minimize Cost, subject to an upperbound on Risk \( \text{Risk} < (1+b)*\text{OptRisk} \)
- Vary the \( b \) parameter to explore the tradeoffs between cost and security

- The Max operator is not quite linear but is easily linearized by defining new variables as follows:
  \[
  \min \{ C_X + a \sum_r \max_p \{ R(p) \cdot \text{ACT}(r,p) \} \} \quad (1)
  \]
  Equivalent to
  \[
  \min \{ C_X + a \sum_r (Y_r) \}
  \]
  With \( Y_r \geq R(p) \cdot \text{ACT}(r,p) \) all \( p \)

Further work

- Experiment with the method on real instances (project REACCESS)
- Modify Security Index if necessary
- Implement Robust Programming ????