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 ??

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Concentration measures

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

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

- Linear version:

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

has a similar but stronger diversification effect

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Linear security index for a multi-regional energy system (e.g. E.U)

$$Min\ [CX + \alpha * SUM_r\ of\ (Max_p\ \{R(p) * ACT(r,p)\}] \quad (1)$$

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)

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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

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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 >> obtain ***OptCost***
  - Minimize Risk only, subject to Cost < (1+a)****OptCost*** >> obtain ***OptRisk***
  - Minimize Cost, subject to an upperbound on Risk

    Risk < (1+b)*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 [CX + α*SUM$_r$ of Max$_p$ {R(p)*ACT(r,p)}] (1)

  Equivalent to

  Min[CX + a*SUMr of (Yr)]

  With Yr >=R(p)*ACT(r,p) all p

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Further work

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

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