ETSAP Workshop and Training Course

Brasilia, Grand Bittar Hotel, November 19-23, 2007

Scenario approach to the evaluation of energy choices
The concept of hedging strategies

Richard LOULOU, Haloa Inc.
GianCarlo TOSATO, IEA/ETSAP

Content

A1 – Definition of scenarios (IIASA-WEC, 1995)

”In designing scenarios we devise images of the future, or better of alternative futures. Scenarios are neither predictions nor forecasts. Rather each scenario is one alternative image of how the future could unfold. Each is based on an internally consistent and reproducible set of assumptions about the key relationships and driving forces of change that are derived from our understanding of history and the current situation. … No analysis can ever turn an uncertain future into a sure thing. … A scenario is an internally consistent and reproducible narrative, describing one possible way the future might unfold”

A2 – Definition of scenarios (IPCC, 1992, 1996)

”Scenarios can also help in improving the understanding of key relationships among factors that drive future emissions. Scenario outputs are not predictions of the future, and should not be used as such; they illustrate the effect of a wide range of economic, demographic and policy assumptions. They are inherently controversial because they reflect different views of the future.”

“The LESS alternatives are not forecasts; rather they are self-consistent constructions indicative of what might be accomplished by pursuing particular technical strategies. These alternative paths to the energy future should be regarded as ”thought experiments” exploring the possibilities of achieving deep reductions in emissions. “

A3 – Definition of scenarios (Schwartz, 1996)

“Scenarios are a tool for helping us to take a long view in a world of great uncertainty. The name comes from the theatrical term "scenario" – the script for a film or play. Scenarios are stories about the way the world might turn out tomorrow, stories that can help us recognize and adapt to changing aspects of our present environment. They form a method for articulating the different pathways that might exist for you tomorrow, and finding your appropriate movements down each of those possible paths. Scenario planning is about making choices today with an understanding of how they might turn out. In this context the precise definition of "scenario" is: a tool for ordering one’s perceptions about alternative future environments in which one’s decision might be played out.”

A4 – Definition of scenarios (1996, 1998)

"Many have tried to understand the future purely through prediction, even though the record to date is poor. Forecasters extrapolate from the past, imposing the patterns they see in the past onto the future, and tend to neglect the oft quoted statement that ‘a trend is a trend until it bends’. And it is the bends that are generally of most interest to us because it is the bends that carry the most risk or offer the greatest opportunities.“ [Davis, 1998]

"The end result [of a present scenario exercise] is not an accurate picture of tomorrow, but better decisions today [about the future]." [Schwartz, 1996]

B – Why using scenarios?

Scenarios are used to take better decisions. This implies:

1. Exploring the future through alternative paths (“exploratory scenarios”)
2. Building “policy scenarios” and evaluate the future impact of choices for each “exploratory scenario”

Other functions:

3. Bookkeeping devices
4. Aids in selling ideas or achieving political ends
5. Aids in communication and education
6. Thinking and training aids to understand the range of possible outcomes

B1a – Function of exploratory scenarios

Government actions or investment decisions are based upon some prior projection exercise. For example, investment decisions in power plants or home insulation are routinely assessed using economic techniques that require assumptions about future energy prices, which depend in part on assumptions about future energy demand. New technologies often come into existence if someone anticipates a market.

Global climate change is a particularly salient example of an environmental problem whose solution requires very long-range projections, imperfect though it may be. At its best scenario building contributes to better social decision-making and minimizes adverse side effects, both direct and indirect.

B1b – Function of exploratory scenarios

Exploratory scenarios can:

- help scientists and policy analysts to identify the main dimensions and drivers that shape those future worlds;
- help them to explore and understand the dynamic links among the main drivers and to assess their relative importance (in terms of potential impacts) as sources of uncertainty;
- allow a more systematic and full appreciation of the uncertainties that lie ahead in the energy and environment domain.

B2a – Function of policy scenarios

However, basing our long-term strategic decisions on the assumption of continuation of present trends presents risks: what if things do not turn out to be as expected? That possibility must be taken into account if we want to have a contingency plan at all. In particular, we need to contemplate the possibility that some critical variables, the ones that have the potentially largest impact in the success of our plan, take a different course. What do we do in that case? And, more generally, what strategy or course of action would maximise our chances of success in a wide range of different situations?

Interestingly enough accurately projecting the future does not appear in the discussion, because <u>the use is of scenarios is for the present, not for the time, which projections refer to</u>.

B2b – Function of policy scenarios

Furthermore, even assuming continuation of present trends we are often obliged to see that those trends may not necessarily lead to desirable outcomes. Trends may be unsustainable under a number of aspects. Developing through logical reasoning the final consequences of those trends may point to some clear dangers down the road. Should we not then try to steer clear of those dangers by modifying our trajectory? The intellectual exercise of looking farther into the future can be extremely useful to provide early warnings, in time for us to engage the possibility of actually modifying our behaviour.

The fact that all scenarios remain inherently speculative in nature diminishes neither their role nor their usefulness, which is mainly to assist in decision-making by offering the possibility of identifying problems, threats and opportunities.

B3 – Scenarios as bookkeeping devices

In this use models are a means to condense masses of data and to provide incentives for improving data quality. Consider an energy projecting model that disaggregates energy use by economic sector and within each sector by broad end-use category. Using this model to project future energy demand, even by trend projections, may point to a lack of good data in some end uses or sectors, thus inducing better data collection. Comparing energy supply data with energy use data may disclose inconsistencies due to reporting errors, overlooked categories, losses, etc. For this purpose a model can be considered useful if it confirms that outputs correctly add up to inputs, or if its use reveals shortcomings in existing data quality and induces improvements in the quality of data collected in the future.

B4a – Scenarios as aids in selling ideas or achieving political ends

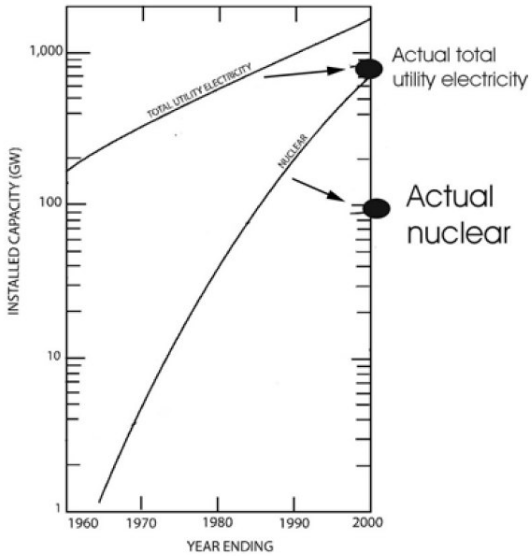


Figure taken from a 1962 report prepared by the U.S. Atomic Energy Commission [JCAE, 1968]

B4b – Scenarios as aids in selling ideas or achieving political ends

The projection was designed to sell nuclear power plants by making the argument for sustained growth in electricity demand. The analysis was based on historic growth rates of total electricity and optimistic projections of the costs of nuclear power. The citation is a Congressional hearing that includes testimony describing the kinds of reasoning used. As a result of this optimism, utilities subsidized early nuclear plant orders (often with considerable help from the government, such as the Price Anderson Act limiting liability). Following the Organization of Arab Petroleum Exporting Countries (OAPEC) oil embargo of 1973 and the oil shock in 1979, electricity growth rates dropped to a few percent per year. The cost of nuclear plants did not decline as predicted, and by the 1980s orders for new plants vanished.

B5 – Scenarios as aids in communication and education

By forcing analysts to discuss data and analysis results in a systematic way, scenario building tools can facilitate communication between various stakeholders. The measure of success for this use is the degree to which the model improves understanding and communication, both for individuals and between groups with different mindsets and vocabularies.

B6 – Scenarios as thinking and training aids to understand the range of possible outcomes

Scenarios can prompt learning and induce desired changes in behaviour. The “Limits to Growth” has been widely used to help students understand the counterintuitive nature of dynamic energy systems [Meadows, 1972].

Scenarios and models can enhance confidence through limiting or bounding cases (available base resources, 1st & 2nd law of thermodynamics, etc.)

Scenarios can help people and institutions think through the consequences of their actions, by comparing “business-as-usual” projections with alternative forecasts

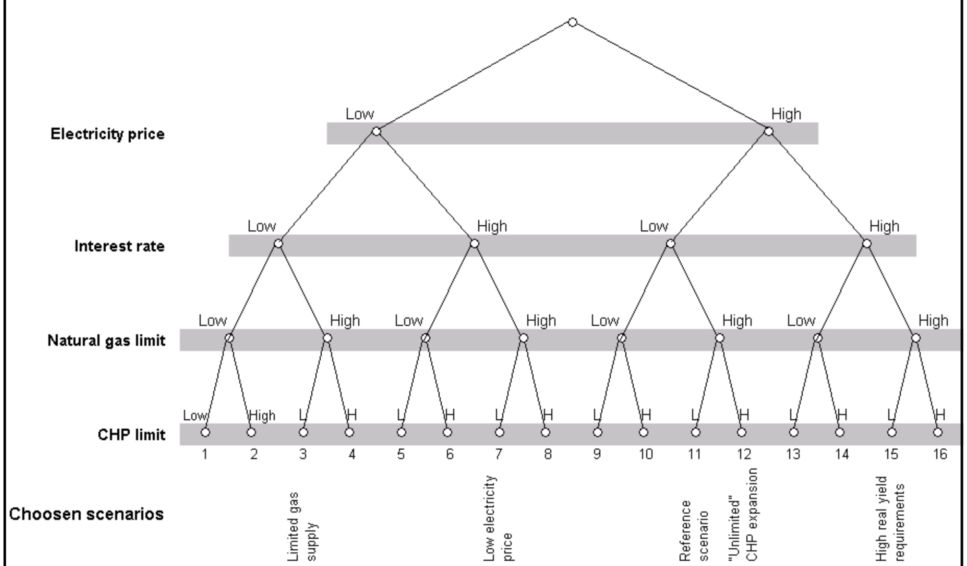
Considering a wide range of scenarios can help institutions prepare for the many different ways the future can evolve.

A scenario approach helps make assumptions explicit.

C – Techniques to build scenarios

1. Analysis of the energy system (identification, quantification)
2. Representation in a model
3. Identification and selection of the exogenous variables:
    1. Uncontrollable
    2. Controllable
4. Selection of useful combinations
5. Compilation of exploratory scenarios
6. Compilation of policy scenarios

C4 – Selection of useful combinations



D – What makes good scenarios?

In long-range projections "success" is a highly subjective term and the measure of success hinges on the intended use of the exercise.

Long-term scenarios are primarily useful for the perspectives they give to current users at the time the forecasts are freshly generated, not to future users.

Scenario studies can be evaluated against

- Their objectives and targets, or
- Their method,
- Quantitative projection, or
- Perception by analysts or the public at large.

D1 – Have scenario objectives been achieved?

A way to judge whether a scenario study has been successful is to identify the original objective and target of the proponents or compilers.

- Did they help identifying the effect of assumptions – technological developments, policies and events?
- Were they instrumental at selling ideas or achieving political aims?
- Did they contribute to policy decisions at some level?
- Did they help for consensus building and shared decision making?

D2 – Was the method adequate?

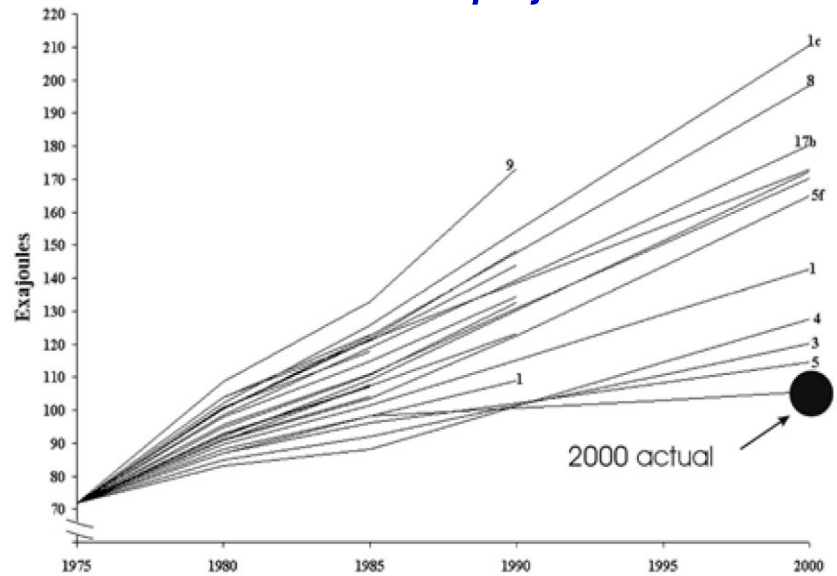
The distinctive feature of scenarios in contrast with simple projections is consistency, internal and with reference to exogenous assumptions. Established modelling methods and rules are normally used to ensure that scenarios not only are consistent, but also reproducible and transparent. Simpler methods make all sort of consistency check easier. However, when the objective of the scenario exercise forces the use of more complex methods and more detailed analyses is twinned to simpler story lines built around inputs and outputs of the model. In every case the most relevant causality chains hidden in thousand equations has to be explained in simple words and intuitive cause-effect chains. Counter-intuitive results have to be clarified.

D3 – Has the scenario the right projections?

The U.S. Department of Energy (DOE) looked back to energy projections to the year 2000 prepared before 1980. As shows, actual U.S. energy use in 2000, which is superimposed on the graph, was at the very lowest end of the forecasts. Energy use turned out to be lower than was considered plausible by almost every expert.

In the very few cases when projections compiled 30 years before are close to statistical values, it is normally the result of wrong combination of wrong assumptions and wrong deductions. But the purpose of building scenarios is not to predict (say in advance) what will happen but to pave the way to more rational / robust decisions.

D3a – An example: USA energy consumption in 2000 has been lower than what projected in the seventies



D4 – How are scenarios perceived?

The assessment of analytical strength is correlated with the views of the reviewers. The Lovins, Ford Energy Policy Project, and Stobaugh and Yergin studies show the extremes most clearly. Both found favour with reviewers favouring renewable sources, whereas analysts who preferred traditional energy systems such as coal and nuclear power found them technically flawed.

Views on study quality were influenced by points of view. Energy policy analysts and policymakers who favoured nuclear power ("traditionalists") disliked both the methodology and the conclusions of the analysts who argued for the feasibility of demand reduction. The "reformists" were equally critical of the analysis of the traditionalists

D4a – Assessment of 12 energy futures studies from the 1970s by two groups of energy experts with different viewpoints about renewable and traditional energy systems *[Greenburger et al., 1983] [A=highest score; Trad., traditionalist group; Refor., reformist group*

Study	Quality[a]		Attention[a]		Influence[a]	
	Trad.	Refor.	Trad.	Refor.	Trad.	Refor.
Ford Energy Policy Project	D	A-	A	B	A	A-
Project Independence Report	C	E	B	B	C	D
ERDA-48 and ERDA 76-1	D	E	D	C	D	D
MOPPS	C	D	D	D	E	E
Ford-MITRE Study	B	B	C	D	A	A-
Lovins "soft paths"	E	A-	A	A	A	A-
WAES Study	C	B	C	C	C	B
CIA assessment of int'l energy	C	B	B	B	B	A
CONAES	B	C	C	C	D	D
Stobaugh and Yergin	D	A	A	A	A	A
RFF-Mellon Study	A	B-	D	D	D	E
Ford-RFF Study	A	A	D	D	D	C

E – Robust strategies

In this area, a strategy can be defined as a set of policy capable of bringing the system towards the intended target.

Analysts build policy scenarios for each exploratory scenario. By comparison, analysts identify the set of policies capable of bending each non intervention scenario toward the target. Some policies appear once or twice, other policies are effective in all (or nearly all) exploratory scenario.

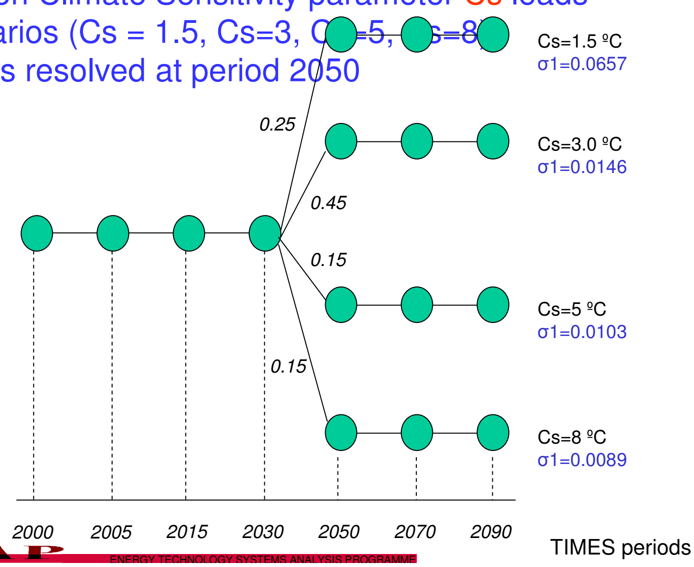
In this sense, a "robust strategy" is the set or policies capable of bending the future towards the intended scenario in the widest range of evolution of uncontrollable variables.

F1 – The need for a single short term strategy

- **One problem with scenarios concerns the early part of the horizon: what should policy makers do if the actions recommended for each scenario are different even in the short term?**
- **So, what should be done in the short term?**
- **<u>Fact</u>: even if the future is uncertain, a <u>single</u> strategy is needed in the short term**

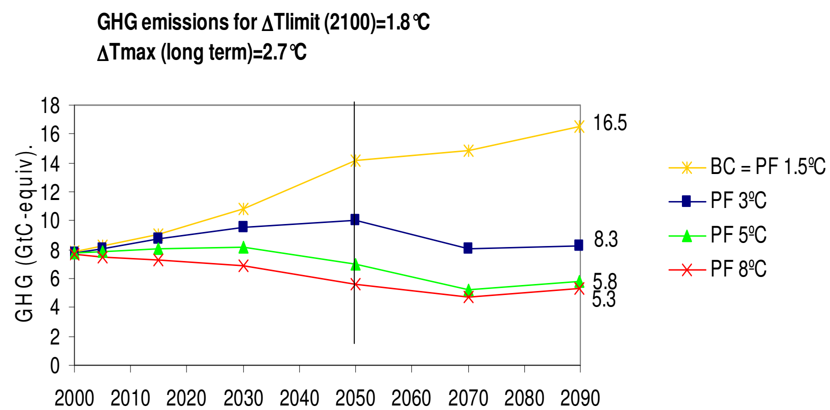
F2 – *Example*:

Uncertainty on Climate Sensitivity parameter Cs leads to four scenarios (Cs = 1.5, Cs=3, Cs=5, Cs=8)
Uncertainty is resolved at period 2050



F3 Example: If the four scenarios are run separately, we obtain four emission trajectories, hwich are all different even in the short term (2010, 2020)

Question: what should be done in 2010-2020?



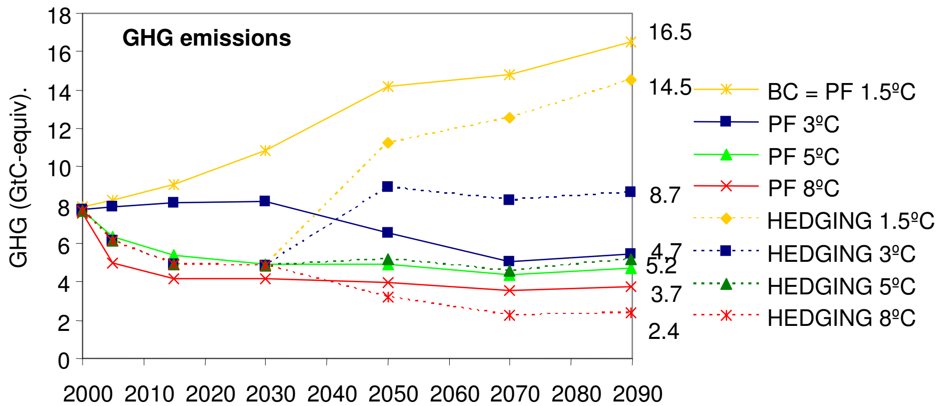
F4 – The need to account for all scenarios

- A strategy that is unique in the short term, but that acknowledges future uncertainties is called a Hedging strategy
- A Hedging strategy is obtained if the policy maker includes in his (her) thinking all possible future scenarios to produce a single strategy, until the uncertainty is resolved
  - **Example 1: a homeowner hedges against many possible futures (fire, theft, hurricane) by insuring his house**
  - **Example 2: a businessman hedges against exchange rate fluctuations by buying a future for a currency**
- In these situations, the policy maker cannot wait until uncertainty is resolved in order to act. He (she) must act NOW

F5 – Example:

The dotted lines represent emissions for a Hedging Strategy:

- **A single trajectory before 2050**
- **Multiple trajectories after (uncertainty is resolved)**



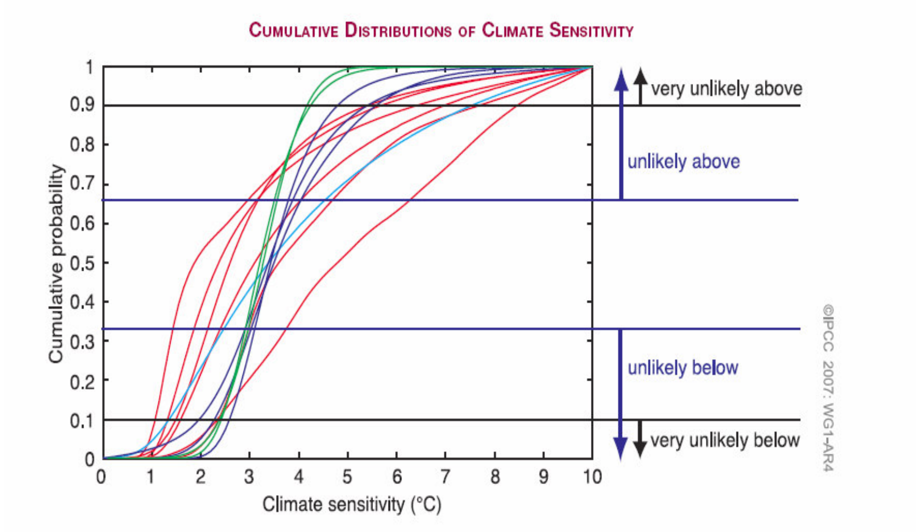
ETSAP ENERGY TECHNOLOGY SYSTEMS ANALYSIS PROGRAMME

F6 – Two examples of randomised scenarios

- Accounting for many uncertain futures has a name: scenario randomisation
- Two types of randomisation:
  - With probabilities assigned to each possible future
    - Example: IPCC (2007) assigns a probability distribution to the unknown climate sensitivity parameter (Cs)
  - Without probabilities

ETSAP ENERGY TECHNOLOGY SYSTEMS ANALYSIS PROGRAMME

F7 – Cumulative distributions of Climate Sensitivity



(The probability distribution can be discretised)

F8 – Two kinds of Hedging strategies in optimisation models

- Probabilistic Scenario approach
  - $\text{Min}_X\ \Sigma\ p^j * C^j X^j$, j is the scenario index
- Non-probabilistic Scenario approach
  - E.g. $\text{Min}_X\ \text{Max}_j$ Regret (X^j) , Robust Programming

Regret (X_j) = difference between cost under strategy j, and minimum under certainty

Regret (X^j) = $C^j X^j$ - Min_{Xj} ($C^j X^j$)

Note: The variables X^j have same values for all j at periods up to the resolution of uncertainty

Conclusion

ENERGY TECHNOLOGY SYSTEMS ANALYSIS PROGRAMME