SUPPORTING ENERGY DECISION-MAKING:
A MULTI-CRITERIA ANALYSIS OF
FRANCE'S 2025 ELECTRICITY GENERATION SCENARIOS

Guillaume Andréa Jérémie Tauzin, GPSS, ID 47-116832
Advisor: Project Associate Professor Masaru Yarime
Co-Advisor: Assistant Professor Tomohiro Akiyama

ABSTRACT

In December 2012, France, the world's most nuclear-powered country on a per capita base, has initiated a national debate on energy transition. In the wake of Fukushima nuclear accident and following the nuclear phase-out of neighboring countries such as Germany, Belgium, and Switzerland, François Hollande, who were to be the next president promised that France will reduce the share of nuclear in total electricity generation from 75% to 50%. However, this decision involves complex conflicting trade-offs among its economic, environmental, and social consequences. Indeed, there is no ideal energy technology that performs well according to all of these sustainability pillars but rather each of them participates in the mitigation of a specific energy issues while nourishing another. At the same time, in France like in most nuclear-powered countries, the decision-making process of energy policies lacks transparency. Energy decisions are made by multiple decision-makers that have different agendas and no expertise in energy-related fields. As a result, there is a need to provide an academic support to ensure that energy decision-making in France is conducted towards an improvement of the sustainability of the energy supply system.

Previous studies have applied decision support technique to provide a structured analysis of energy decision options against multiple objectives all over the world. Multi-Criteria Analysis (MCA) has been seemingly adopted by the scientific community as the new standard analytical framework for

decision support. MCA has the capacity to deal with a broad range of economic, environmental, and social concerns and integrate them in the decision-making process so that the solution optimally fitting decision-makers' objectives and preferences is found. However, in the case of France, academic attention in energy decision support is scarce and energy decision support studies are conducted by a government-ordered commission of experts. In 2011, a comparative analysis of electricity generation scenarios for 2050 were conducted but turned out to be very controversial as independent energy experts' critiques pointed out the two main issues: their lack of objectivity and the limitation to an economic approach of energy decisions. Indeed, most of the scenarios assessed were from the industry involvement and independent experts revealed a number of factual mistakes and methodological bias. Furthermore, the decision criteria focusing on economic concerns and socio-environmental impacts were assimilated to local CO_2 emissions and acceptance of the noise from wind turbines. The issue of nuclear wastes disposal or safety of the power plant were barely mentioned. Decision support in France appears therefore as behind the academic standard of decision support in term of both structure and integration of socio-environmental aspects.

The objective of this study is to evaluate the energy transition plan in France while filling the gaps of the previous French energy decision-support studies. The present study has been built on the MCA framework. Among the potential 2025 electricity supply strategies, the four categories were identified leading to the elaboration of four representative scenarios. The life extension of historical nuclear power plants is represented by the Business-As-Usual (BAU) scenario. Furthermore, three transition scenarios were built. First, a slow transition (SLO) scenario to less nuclear power that represents an acceleration of the commissioning of third generation of nuclear reactors. Then, two direction of nuclear energy share reduction to 50% by 2025 were analyzed: 50% nuclear with High

Renewable Energies (HRE) scenario and the 50% nuclear with High Fossil Fuels (HFF) scenario. Then, the four scenarios were assessed from the perspective of electricity generation costs based on Levelized Cost Of Electricity (LCOE) calculations and of socio-environmental impacts gathered in five categories: impact on ecosystems, resources availability, human health, hazardous waste, and safety. Finally, a trade-offs analysis between the economic performance of scenarios and their socio-environmental impacts were conducted at three different levels of scale, from overall trade-offs to detailed bi-dimensional trade-off of costs against each socio-environmental indicator.

The result showed that the decision of whether to initiate the transition itself is subjected to significant compromise. Indeed, the BAU scenario represents a very cost competitive option and has the lowest impacts on ecosystems and health as well as climate change. Nevertheless, the issues of radioactive waste, ionizing radiations and accidental consequences are particularly significant with this scenario. As for SLO transition scenario, it is at the core of trade-offs between very high cost and maximum accidental consequences, still high radioactive waste generation and relatively low greenhouse gases emissions compared to other transition scenario. As for, HRE transition scenario, it involves moderated cost socio-environmental impacts except for climate change and ozone depletion, which are very high. HFF transition scenario has very high impact according to almost every socio-environmental scenario but is also the least expensive transition scenario. But, for HRE and HFF, the nuclear-related impacts such as nuclear wastes, maximum accidental consequences and ionizing radiations are logically decreasing along with nuclear energy share in the mix. Furthermore, the internal analytical results were confronted to external aspects related to the economic context (financial crisis, energy industry, volatility of fuel prices or employment), the environmental context (climate change, radioactive waste) and the socio-political context (acceptance, electricity exports, diplomacy).

As an outcome, this study proposes a combination of the trade-offs analytical results and contextualization factors in the form of easy-to-understand SWOT analysis for each scenario. Recommendations to decision-makers include the improvement of the transparency of the decision-making process in order to make possible a concrete integration of decision support studies. Also, socio-environmental concerns in the decision-making process should be systematically included in energy decision-making processes as they are too often informally considered leading the way to hasty generalizations and subjectivity. Further research should also follow those direction by extending the present study effort to the development of a decision-making support framework based on decision-makers' interests and preferences..

Key words: decision analysis, sustainable energy, multi-criteria analysis, trade-off analysis, France