Swiss electricity supply options in focus

The sustainability of the current and future power-supply technologies relevant to Switzerland has been analyzed within the context of a comprehensive, interdisciplinary study. The evaluation is based on both the total-cost approach, and on the multi-criteria aggregation of ecological, economic and social indicators. The use of total costs leads to a clear ranking of the technological options, with the social dimension represented only to a limited extent. In contrast, the ranking resulting from the multi-criteria approach explicitly incorporates a wider spectrum of social aspects as well as stakeholder preferences.

The goal of the study was to produce an interdisciplinary evaluation of current and future electricity-generating systems, operating under Swiss-specific conditions. The project was coordinated by the major Swiss energy supplier, Axpo. In addition to PSI, the participants included the University of Stuttgart, the Centre for Energy Policy and Economics (CEPE) at the Swiss Federal Institute of Technology, Zurich (ETHZ), and BAK Basel Economics.

Scope and methods

The sustainability assessment employing Multi-Criteria Decision Analysis (MCDA) was defined in terms of a total of 75 criteria, with the associated indicators quantified for the years 2000 and 2030. To a large extent, current technologies were taken from the best commercially available options, while a wide spectrum of evolutionary concepts was included for the future technologies. Compared to earlier studies, which focused on power technology assessments in Switzerland [1], Germany [2] and China [3], the present work embodies much greater diversity of technologies, and employs a much broader set of evaluation criteria and indicators.

Along with the modelling of power plants and their associated energy chains, the task of PSI included the full ecological aspect, as well as numerous social and economic criteria. The principal ecological criteria are greenhouse-gas emissions, consumption of resources, waste, and impact on ecosystems. PSI's contributions to the economic and social indicators consisted, among other elements, of providing estimates of electricity generation costs, as well as damage to health resulting from both normal plant operation and severe accidents.

Life Cycle Assessment (LCA) forms the basis for the quantification of ecological indicators. The approach does not take into account site dependencies, though this aspect is covered within the quantification of health and environmental damage due to air pollution from the various energy chains, which is based on the state-of-the-art *Impact Pathway Approach*, as defined in recent projects within the ExternE-series [4,5]. The background LCA database was ecoinvent v1.2, reflecting conditions in year 2000 [6].

The analysis of accident risk is based on historical experience (as reflected in the PSI database ENSAD [7]), and site-specific, simplified Probabilistic Safety Assessment (PSA). Economic indicators are built on extensive literature studies, earlier experience, input from industry, and, where appropriate, on expert judgement.

Selected results

Results presented here are based exclusively on the work at PSI. Figure 1 shows environmental indicators for the year 2030. For each indicator, the results are normalized (with 100% assigned to the worst-performing technology). Hydropower is superior in terms of minimal environmental impact; otherwise, the picture is diverse.

The total cost of electricity supply (internal production costs plus external costs resulting from health and environmental damage) constitutes a possible aggregate measure of sustainability (Figure 2). Nuclear power has the lowest total costs, both now and in 2030. External costs of fossil-fuel technologies are dominated by the damage caused by global warming (though estimates of this are highly uncertain). Some of the currently expensive renewable options will become more competitive later. Consideration of external costs improves the competitiveness of the renewables and nuclear power options in comparison to those based on fossil fuels.

The total cost approach is very useful for carrying out cost-benefit analyses, but its use in the assessment of the relative sustainability of the various options is not yet fully accepted. The main objections derive not only from limited coverage of social aspects, but from the acceptability of monetary values being applied to a few of the social indicators that have been explicitly addressed. Consequently, MCDA has been employed to provide an alternative quantification of the aggregate sustainability indicator. The complete MCDA model, with 75 criteria (some not readily amenable to monetization: e.g. risk perception and political stability), does allow for the consideration of individual or group preferences through assignment of appropriate weighting factors.

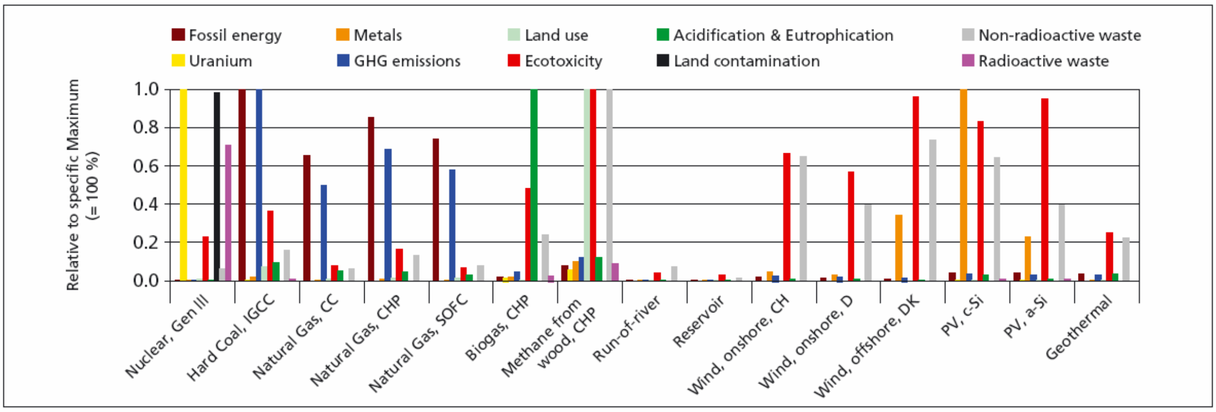

Figure 1: *Environmental indicators for electricity generation in 2030 (not all of the options analysed are shown). Gen III = 3rd generation reactor; IGCC = Integrated Gasification Combined Cycle; CC = Combined Cycle; SOFC = Solid Oxide Fuel Cell; CHP = Combined Heat and Power.*

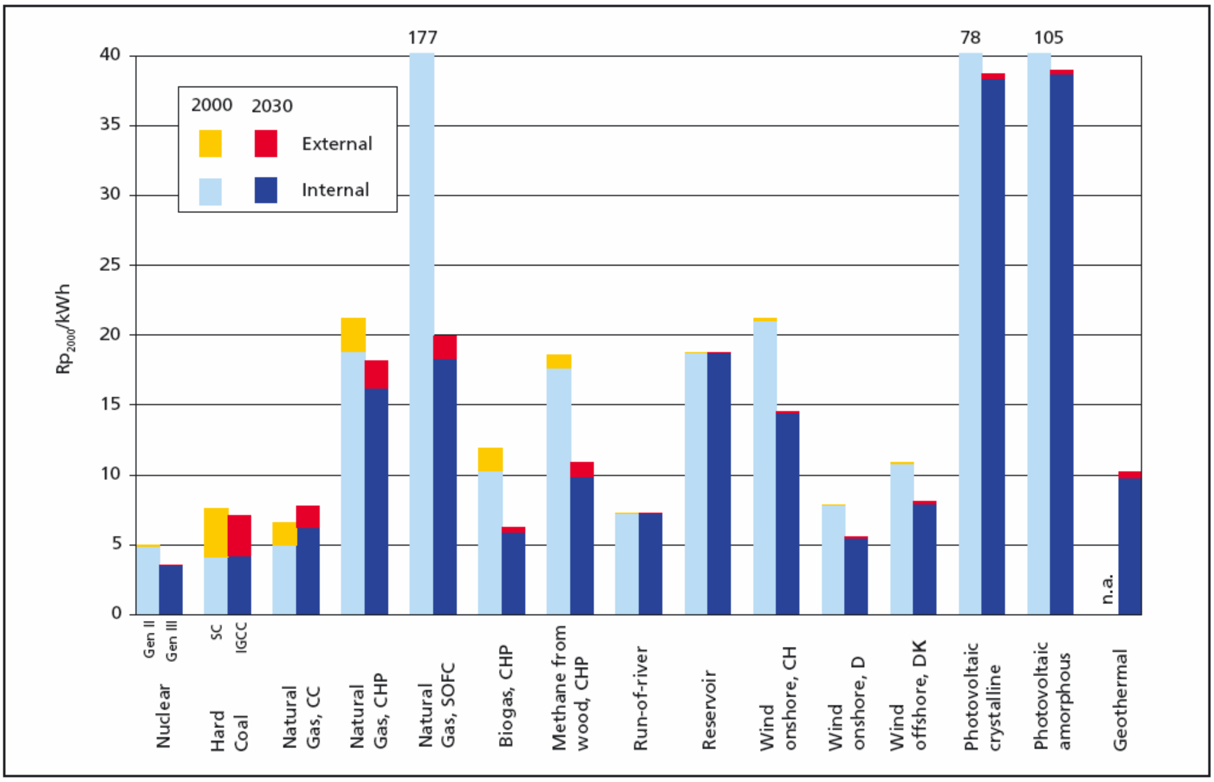

Figure 2: *Full costs of electricity generation options in 2000 and 2030. (Gen II/III = Generation II and III reactors; SC = Supercritical; IGCC = Integrated Gasification Combined Cycle; CC = Combined Cycle; CHP = Combined Heat and Power; SOFC = Solid Oxide Fuel Cell)*

References

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