Swiss energy strategies under nuclear and climate policy constraints

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The Energy Economics Group at PSI is undertaking some of the first integrated analysis of the Swiss energy sector and climate change mitigation strategies under global uncertainties. Nowadays, these global uncertainties include global resource availability, climate policies and, as a consequence of the recent accident in Fukushima, Japan, nuclear policies. We find that the consequences of the nuclear phase-out in Switzerland for the achievement of climate mitigation targets include the need for additional energy efficiency measures, the integration of larger shares of intermittent renewables and trade-offs with electricity independence.

The nuclear accident at Fukushima, Japan, in March 2011, increased worldwide uncertainty regarding nuclear policy. In Switzerland, the Federal Council decided in May 2011 to phase out nuclear power by not replacing existing plants at the ends of their respective lives [1]. In addition, Switzerland has an ambitious target of reducing domestic greenhouse gas emissions by 60% by 2050 (compared with 1990 levels) [2]. Given that nuclear power accounts for around 40% of current Swiss electricity generation, the Council's decision raises important questions concerning alternative technologies and energy-saving measures needed to achieve these targets. Furthermore, available strategies for Switzerland are likely to be affected by global or regional energy-related decisions. In this work, we analyze the possible effect of changes in global and domestic technology preferences after the recent nuclear accident at Fukushima on the development of the Swiss energy system.

Approach and methodology

We address this question by exploring different scenarios of global and regional technology preferences under a stringent climate mitigation policy (a long-term global target for atmospheric CO_2 concentration of 400 ppm, which corresponds, according to the IPCC [3], to a "best estimate" global mean temperature change of 2.4 °C and is consistent with the Swiss domestic target mentioned above). These scenarios are 'what if' analyses – rather than predictions – of the future energy system, which contribute to identifying robust technology pathways and possible challenges associated with climate change and energy policies.

To develop this scenario analysis, we use MERGE-ETL, an integrated assessment model that represents the linkages between the economy, energy sector and climate [4]. We modified the regional definition of the model to better represent geopolitical groups and to distinguish Switzerland, which allows us to study the effects of global factors and policies on technology pathways for the Swiss region. MERGE-ETL includes a range of technologies to supply electricity and non-electric energy, comprising fossil fuel resources, such as oil, coal, gas; nuclear power plants (light water and fast breeder reactors); as well as renewable-based technologies. For some of the less mature technologies, the model accounts for the possibility of technology learning (i.e. improvements to the technology) arising from experience during development, production and use.

Climate and nuclear policy results

Figure 1 compares global and Swiss electricity production with and without a stringent climate target (Clim and BAU, respectively), but with light water reactors available – fast reactors are not considered. The climate policy leads to a decrease in electricity demand, due mainly to the deployment of more-

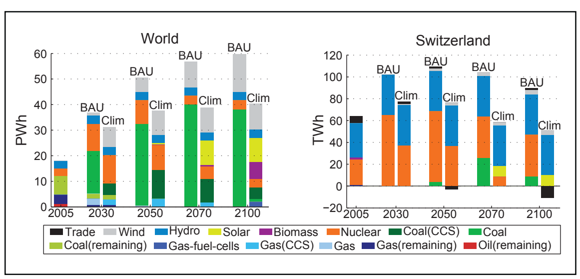

Figure 1: **Electricity production in 'business- as-usual' and climate policy scenarios.**

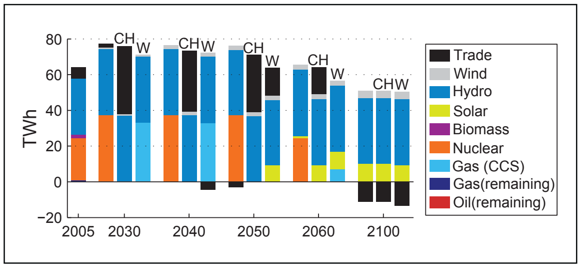

Figure 2: **Swiss electricity production in climate policy scenarios with and without nuclear generation.**

efficient demand-side technologies. Moreover, renewable, nuclear and carbon capture technologies become the preferred options to supply electricity worldwide, replacing the fossil fuel power plants preferred in the absence of climate mitigation policies. Nuclear power makes an important contribution to electricity generation in the first half of the century; however, global depletion of uranium resources leads to a worldwide reduction in the share of nuclear generation after 2050. In Switzerland, the availability of low-carbon hydropower and solar alternatives enables a complete substitution of nuclear after 2070.

Although nuclear energy has the potential to play a major role in the future energy system, whether this potential can be realized has become highly uncertain given recent events in Fukushima. Accordingly, we explored some of the implications of a domestic – in Switzerland and Japan – and a global moratorium on the construction of new nuclear power plants. If only Switzerland and Japan opt for such a policy, the global energy system remains relatively unchanged, while a global no-nuclear policy implies additional electricity efficiency measures and the integration of a large share of intermittent renewables. In Switzerland, Figure 2 shows that the domestic-only moratorium results in a large reliance on imports (in effect, the Swiss reactors shift to the EU). This produces only minimal economic effects, but implies a reduction in self sufficiency that may not be acceptable to Swiss policymakers. In contrast, when the whole world implements the same policy (W in Figure 2), Switzerland's access to cheap low-carbon electricity imports becomes limited, requiring more drastic action, including further reductions in electricity demand, earlier deployment of renewable generation and the use of natural-gas combined-cycle generation with carbon capture as a transition technology.

For Japan, access to electricity imports is limited in all cases, so a domestic phase-out of nuclear power requires significant changes to the energy system, while a global phase-out of nuclear has relatively little additional effect.

The nuclear moratorium has important economic consequences in the realization of the global climate target. Figure 3 presents the GDP losses (compared to the BAU scenario) associated with achieving the climate target for each scenario on nuclear availability. Swiss and global GDP losses in the global no-nuclear scenario increase substantially in the periods when nuclear energy would otherwise be highly competitive, due to earlier investment in solar technologies and additional efficiency measures. However, if only Switzerland and Japan forgo nuclear, global economic costs are similar to the scenario with nuclear and Swiss GDP losses are substantially lower (although reliance on imports is greatly increased). Swiss GDP losses are generally lower than global losses because the Swiss electricity sector is already relatively decarbonized in the BAU scenario.

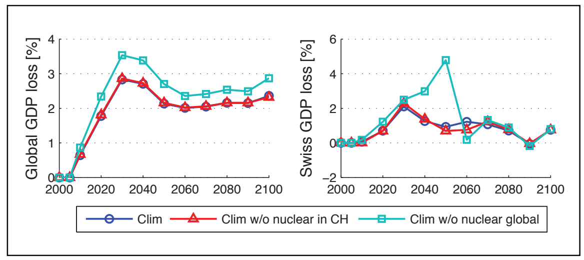

Figure 3: **Economic costs of climate mitigation, global and for Switzerland.**

In summary, the results indicate that stringent mitigation targets under a nuclear moratorium imply important changes to the Swiss and global energy systems, including a larger use of renewables, the deployment of natural gas, with carbon capture as a transition technology, and a considerable reduction in electricity demand, requiring extensive efficiency measures.

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References

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