Sustainability, neutrality and beyond in the framework of Swiss post-2012 climate policy

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International Energy Workshop - Venice - 17-19 June 2009
Objectives and contributions

Objectives

- Assess ambitious Swiss post-Kyoto climate policy;
- Focus on the residential sector;
- Consider the international framework;
- Improve the coupling procedure.

Contributions

- Improved coupling of existing top-down and residential bottom-up models;
- Integrated assessment of post-2012 climate policies in various international frameworks.
Households are responsible for 12 MtCO₂ in 2005 i.e.:

- more than 50% of the CO₂ emissions due to combustible fuels
- 22.3% of total GHG emissions

**Modeling requirement**

- Model precisely the residential sector
- Integrate the residential modeling in a global framework
Outline

1. Introduction

2. The models
   - GEMINI-E3
   - MARKAL-CHRES
   - Coupling rationale

3. Coupling methodology

4. Policy scenarios

5. Results

6. Summary and further research
Main characteristics of GEMINI-E3

- Dynamic-recursive CGE model of the world economy;
- Aggregated version in 6 regions (CHE, EUR, OEU, JAP, OEC and DCS);
- 5 energy sectors;
- 13 non-energy sectors;
- All GHG Emissions (EMF 21);
- 2001 Swiss SAM prepared on the basis of the new Swiss IO table (ETH Zürich) and GTAP 6;
- GTAP 6 (2001) for other countries;
- Nested CES utility function;
- Global GHG emission certificates market.
Nested CES utility function

- **Total consumption**
  - $\sigma^c_{hc} = 0.2$

- **Housing**
  - $\sigma^{hres} = 0.5$

- **Transport**
  - $\sigma^{htra} = 0.5$

- **Other**
  - $\sigma^{hoth} = 0.3$

- **Energy**
  - $\sigma^{hre} = 0.8$
- **Other**
  - $\sigma^{hres} = 0.5$
  - (17)

- **Purchased**
  - $\sigma^{htrap} = 0.5$

- **Private**
  - $\sigma^{htrao} = 0.3$
  - (16)

- **Equipment**
  - (16)

- **Energy**
  - $\sigma^{htraoe} = 0.8$

- **Gas Petroleum Electricity products**

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We have also introduced an emission certificates market that allows for modeling a global cap and trade system. Each region receives annually an endowment of emission certificates, equal to the emission policy target. In Switzerland, we have also implemented an exogenous progressive GHG tax, independent from the global price of certificates that allows for higher domestic abatement.

2.1.1 Measuring the cost of GHG abatement

Climate policies are devised in order to avoid future welfare losses induced by the potentially costly damages and adaptation measures entailed by changes in climate if no mitigation effort is undertaken. It is not the aim in this paper to consider the tradeoff between adaptation and mitigation measures but rather to measure the costs for the society to abate GHG emissions. Measuring the costs of climate policies and comparing their efficiencies can be done in various ways. A simple approach consists in analyzing the variation of macroeconomic aggregates such as GDP or households' final consumption (HFC). Unfortunately, the variation of GDP and HFC does not account for the variation of relative prices induced by the introduction of a GHG tax. The households' surplus, either based on the compensative variation of income (CVI) or the equivalent variation of income, is a more consistent and complete measure of...
Main characteristics of MARKAL-CHRES

- Linear programming model of the Swiss residential energy system (MARKAL family)
- Perfect information and perfect foresight
- 173 technologies (including energy saving technologies)
- 13 End-use demands exogenously set (drivers)
- Calibrated on Swiss statistics and IEA data (2000)
- 5% discount rate
Comparison of GEMINI-E3 with the coupled model
MAC curves in 2020 (left) and 2050 (right)

A. Sceia, J.-C. Altamirano-Cabrera, L. Drouet, T.F. Schulz, and M. Vielle.
Integrated assessment of Swiss GHG mitigation policies after 2012 - focus on the residential sector.
Objective: find the tax that equalizes the tax revenue in the target year and the purchase of certificates ensuring to meet the total target, possibly ensuring a minimum domestic abatement (double target);

- 3 coupling variables: residential fuel mix, residential investments matrix and energy prices;
- CES residential nest changed to Leontief ($\sigma_{hres} = \sigma_{hrese} = 0$);
- the fuel mix and the annualized investments are used to define the fuels share parameters as well as the technical progress of residential energy and of the residential construction;
- The variation of energy prices are aligned between the models.
Introduction
The models
Coupling methodology
Policy scenarios
Results
Summary and further research

Figure 2 presents the coupling schema. The GHG progressive tax vector, defined by the value of the tax in 2050, is the variable that allows to control both models. The residential fuel mix and the annualized investments over the whole time frame are the coupling variable ensuring that GEMINI-E3 calculates emissions and adjusts the residential investments in GEMINI-E3 on the basis of the MARKAL-CHRES simulations. The fuel shares are used as a proxy for the variation of the share parameters in the residential energy nest, which elasticity is set to 0, whereas the variation of the total fuel consumption and the variation of annualized investments are used, respectively, to update the values of the technical progress on energy and on construction in the residential nest, which is also transformed into a Leontief function. Furthermore, total Swiss emissions and world price of GHG certificates in 2050 are the variables used for ensuring that the coupled models converge to the targets defined in the scenarios. Finally, the international policy scenarios are set exogenously, i.e. defining emissions certificates endowments.

A technical description of the coupling procedure is provided in algorithms 1 and 2 (see appendix A).
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Policy scenarios

- We analyze 4 scenarios implementing a progressive GHG tax:
  1. 50%;
  2. “sustainable” (75%);
  3. “neutral” (100%);
  4. “zero footprint” (180%).

- Scenarios are also considered with and without a minimum domestic GHG emissions abatement of 50% (+).

- 3 international abatement frameworks (low, mid and high).
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International GHG emissions (MtCO$_2$eq)

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Sustainability, neutrality and beyond
## Summary results for Switzerland

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Abatement in 2050a</th>
<th>Swiss taxb</th>
<th>GHG pricec</th>
<th>2008-2050d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Domestic</td>
<td>Total</td>
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<td>WG</td>
</tr>
<tr>
<td>World</td>
<td>Switzerland</td>
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<td></td>
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<tr>
<td>Low</td>
<td>50%</td>
<td>-28</td>
<td>-50</td>
<td>1.2</td>
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<tr>
<td></td>
<td>neutral</td>
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<td>-100</td>
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<tr>
<td></td>
<td>50%+</td>
<td>-50</td>
<td>-50</td>
<td>102.4</td>
</tr>
<tr>
<td></td>
<td>zero-footprint+</td>
<td>-50</td>
<td>-180</td>
<td>102.4</td>
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<tr>
<td>Mid</td>
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<td>-40</td>
<td>-100</td>
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<tr>
<td></td>
<td>neutral+</td>
<td>-50</td>
<td>-100</td>
<td>101.9</td>
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<tr>
<td>High</td>
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<td>-39</td>
<td>-50</td>
<td>50.7</td>
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<tr>
<td></td>
<td>sustainable</td>
<td>-50</td>
<td>-75</td>
<td>143.7</td>
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<tr>
<td></td>
<td>neutral</td>
<td>-54</td>
<td>-100</td>
<td>290.7</td>
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<tr>
<td></td>
<td>zero-footprint</td>
<td>-63</td>
<td>-180</td>
<td>926.5</td>
</tr>
<tr>
<td></td>
<td>50%+</td>
<td>-50</td>
<td>-50</td>
<td>149.2</td>
</tr>
</tbody>
</table>

a % of 2001 emissions  
b Swiss tax in 2050 [USD$_{2001}$/tCO$_2$eq]  
c World price of certificates in 2050 [USD$_{2001}$/tCO$_2$eq]  
d Sum of discounted values as % of the sum of discounted final households consumption (5% discount rate)
Fuel consumption in the residential sector

![Graph showing fuel consumption in 2020 and 2050 for different policy scenarios.](image)

- **2020**
- **2050**

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Summary and further research

- High domestic abatement costs in Switzerland;
- Purchasing GHG certificates does not prepare Switzerland in case the contraction and convergence principle is retained in future international climate agreements;
- A progressive GHG tax of 100-150 USD/tCO$_2$eq is required to achieve a 50% domestic abatement by 2050;
- Ambitious policy targets ensuring a important domestic emission abatement are affordable even with stringent international policy agreement;
- The impact on GDP and welfare are limited.

Couple a bottom-up model for the transport sector.
Summary and further research

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- The impact on GDP and welfare are limited.

- Couple a bottom-up model for the transport sector.
Tax revenue used to purchase GHG certificates for 50% total abatement
Policy scenarios (cont.)

Table: International emissions targets in 2050 (% of 2001 emissions)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>EUR</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>OEU</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>JAP</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>OEC</td>
<td>30</td>
<td>40</td>
<td>50</td>
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<tr>
<td>DCS</td>
<td>-</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>

\(^a\) % of 2030 emissions

\(^b\) baseline emissions

![Graphs](image-url)
### Dimensions of the complete GEMINI-E3 Model

<table>
<thead>
<tr>
<th>Countries and Regions</th>
<th>Sectors/Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annex B</strong></td>
<td>Energy</td>
</tr>
<tr>
<td>Germany</td>
<td>01 Coal</td>
</tr>
<tr>
<td>France</td>
<td>02 Crude Oil</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>03 Natural Gas</td>
</tr>
<tr>
<td>Italy</td>
<td>04 Refined Petroleum</td>
</tr>
<tr>
<td>Spain</td>
<td>EUR 05 Electricity</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Non-Energy</td>
</tr>
<tr>
<td>Belgium</td>
<td>06 Agriculture</td>
</tr>
<tr>
<td>Poland</td>
<td>07 Forestry</td>
</tr>
<tr>
<td>Rest of EU-25</td>
<td>08 Mineral Products</td>
</tr>
<tr>
<td>Switzerland</td>
<td>09 Chemical Rubber Plastic</td>
</tr>
<tr>
<td>Other European Countries</td>
<td>10 Metal and metal products</td>
</tr>
<tr>
<td>Russia</td>
<td>OEU 11 Paper Products Publishing</td>
</tr>
<tr>
<td>Rest of Former Soviet Union</td>
<td>12 Transport n.e.c.</td>
</tr>
<tr>
<td>United States of America</td>
<td>13 Sea Transport</td>
</tr>
<tr>
<td>Canada</td>
<td>14 Air Transport</td>
</tr>
<tr>
<td>USA Australia and New Zealand</td>
<td>15 Consuming goods</td>
</tr>
<tr>
<td>Japan</td>
<td>16 Equipment goods</td>
</tr>
<tr>
<td><strong>Non-Annex B</strong></td>
<td>17 Services</td>
</tr>
<tr>
<td>China</td>
<td>18 Dwellings</td>
</tr>
<tr>
<td>Brazil</td>
<td>Primary Factors</td>
</tr>
<tr>
<td>India</td>
<td>Labor</td>
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<tr>
<td>Mexico</td>
<td>Capital</td>
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<tr>
<td>Venezuela</td>
<td>Energy</td>
</tr>
<tr>
<td>Rest of Latin America</td>
<td>Fixed factor (sector 01-03)</td>
</tr>
<tr>
<td>Turkey</td>
<td>Other inputs</td>
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<tr>
<td>Rest of Asia</td>
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<tr>
<td>Middle East</td>
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<tr>
<td>Tunisia</td>
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<tr>
<td>Rest of Africa</td>
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</table>

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## MARKAL-CHRES Demand segments

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC1</td>
<td>Cooling</td>
</tr>
<tr>
<td>RCD</td>
<td>Cloth Drying</td>
</tr>
<tr>
<td>RCW</td>
<td>Cloth Washing</td>
</tr>
<tr>
<td>RDW</td>
<td>Dish Washing</td>
</tr>
<tr>
<td>REA</td>
<td>Other Electric</td>
</tr>
<tr>
<td>RH1</td>
<td>Room-Heating Single-Family Houses (SFH) existing building</td>
</tr>
<tr>
<td>RH2</td>
<td>Room-Heating SFH new building</td>
</tr>
<tr>
<td>RH3</td>
<td>Room-Heating Multi-Family Houses (MFH) existing buildings</td>
</tr>
<tr>
<td>RH4</td>
<td>Room-Heating MFH new buildings</td>
</tr>
<tr>
<td>RHW</td>
<td>Hot Water</td>
</tr>
<tr>
<td>RK1</td>
<td>Cooking</td>
</tr>
<tr>
<td>RL1</td>
<td>Lighting</td>
</tr>
<tr>
<td>RRF</td>
<td>Refrigeration</td>
</tr>
</tbody>
</table>
Sectoal production change due to the policy scenarios
Residential sector’s contribution to domestic abatement

Low - 50%

Low - 50%+

Low - Neutral

Mid - Neutral

High - Sustainable

High - Neutral

Legend:
- Other abatement
- Residential abatement
- Other emissions
- Residential emissions
- Total emissions
- Baseline