SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Global Observatory of Electricity Resources

Peter Burgherr et al.
13.09.2016

In cooperation with the CTI

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Schweizerische Eidgenossenschaft
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Swiss Confederation

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  - Swiss TIMES Energy System Model (STEM)
  - Meta Analysis of Scenarios
  - ENSAD v2.0
  - Spatial MCDA

- Energy Perspectives Update & Extension (S. Hirschberg et al.)

Persons Involved

PIs:

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EE

CO = Coordination
LCA = Life Cycle Assessment
EIA/EC = External Impact Assessment / External Costs
RA = Risk Assessment
TC = Technology Characterization
IA = Integrated Assessment
MCDA = Multi-Criteria Decision Analysis
EE = Energy Economics

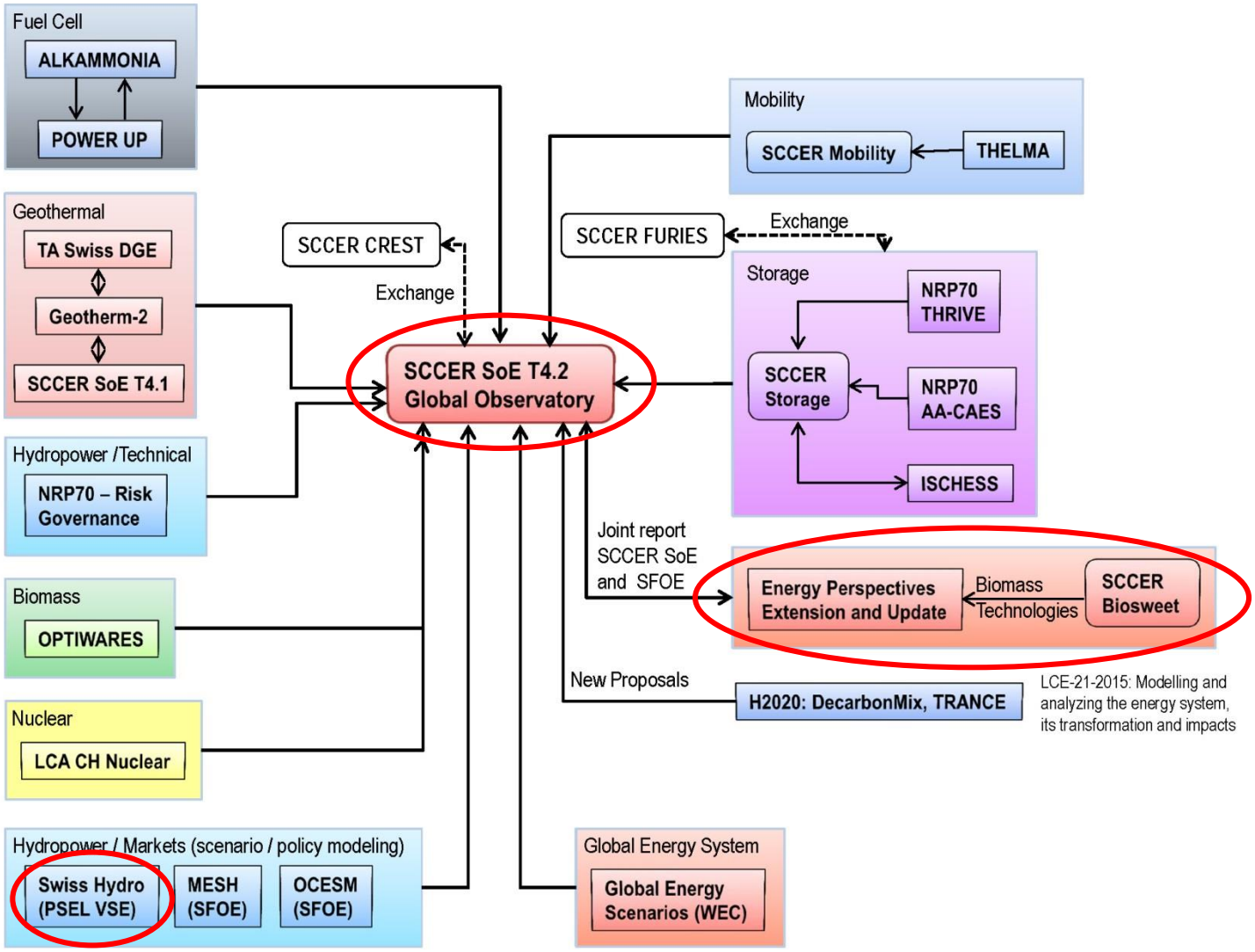
Goals and Tasks

Phase 1 (until end of 2016):

- Trend-based and comparative perspective on the prospective developments of technologies
  - TA: Characterization and sustainability assessment of current and future technologies
  - EE: Evaluation of existing trends, projections and scenarios
  - **Milestone T4.2.1**: Report on global evolution of electricity resources and market (12/15)

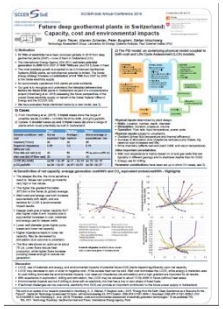
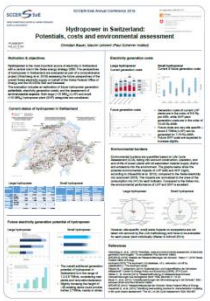
- **Additional Goals (12/2016):**
  - **Energy Perspectives: Update & Extension (T4.2)**
  - **Meta-Analysis of Energy Scenarios (T4.2)**
  - **Accident database: ENSAD v2.0 (T4.1 & 4.2)**
  - **Probabilistic accident risk assessment for hydropower (T4.1)**
  - **Updated and extended geothermal risk indicators (T4.1)**

Global Observatory Project Interactions



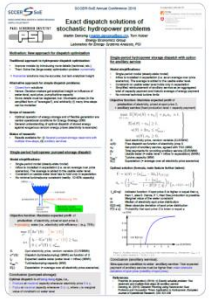
Ongoing Activities

Energy Perspectives Extension & Update

- Perspectives for Swiss Electricity Supply
- Future deep geothermal plants in CH
- Hydropower in Switzerland

Scenario Modeling



- Exact dispatch solutions of stochastic hydropower problems

Comparative Risk Assessment





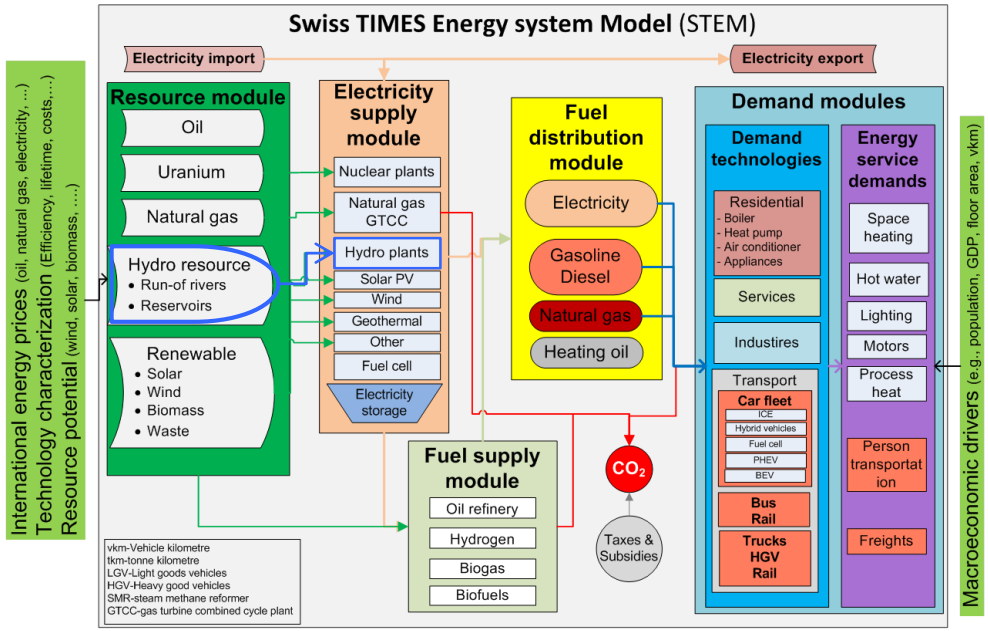
- ENSAD v2.0 (T4.1 & 4.2)
- Hydropower risks (T4.1)
- Geothermal risk indicators (T4.1)
- Hydrogen accident risk (T4.2)

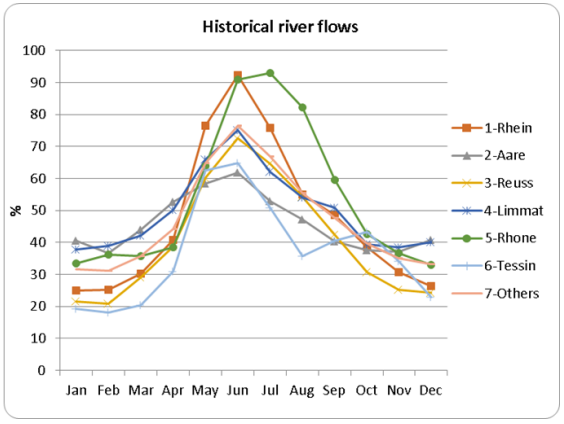
Swiss TIMES Energy System Model (STEM)

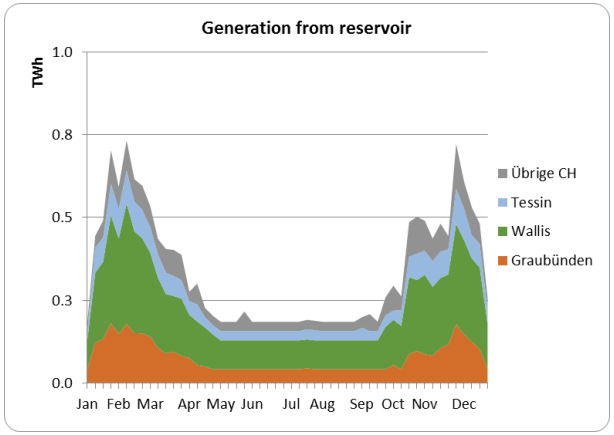
- A ***whole energy system*** model of Switzerland in (cost) ***optimization*** framework
- Long time horizon & hourly representation

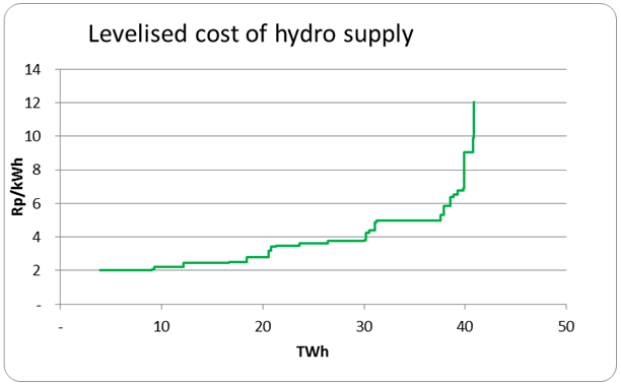
Enhancement in Hydro module *(VSE)*

- River hydro plants by river basins
- Dam hydro by major reservoirs
- Historical availability of resources
- Existing and new resource potentials









Meta-Analysis (Example: Supply Mix 2050)

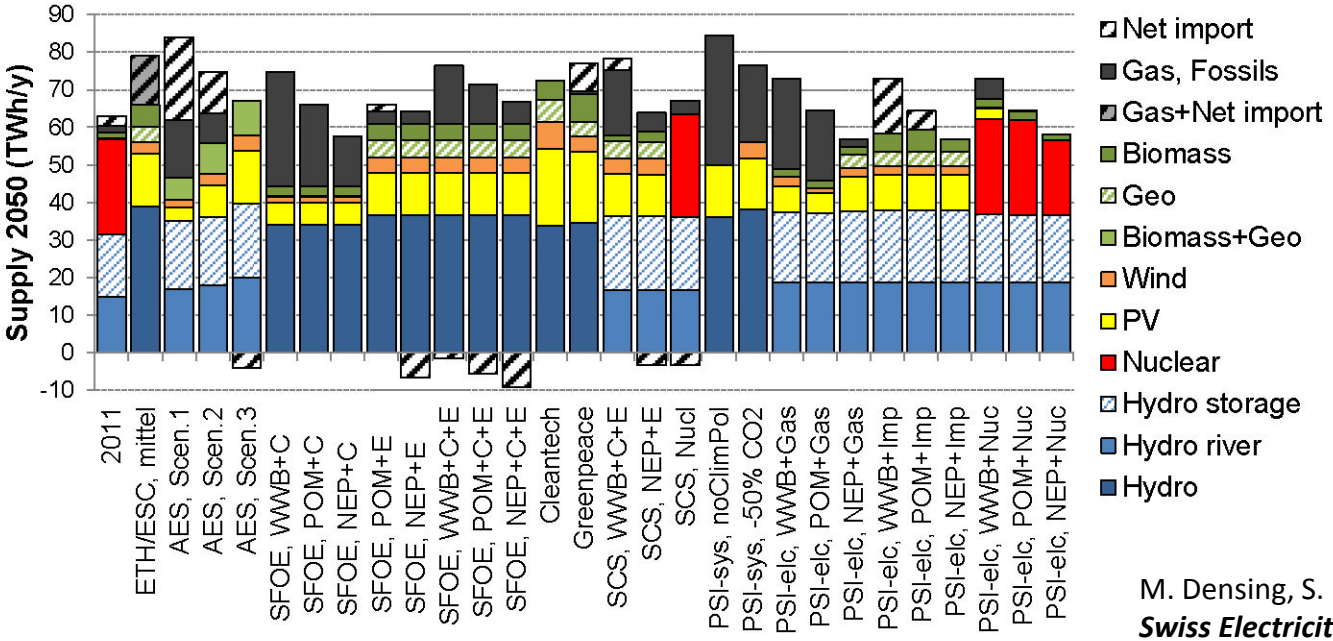
Goals of meta-analysis of a scenarios over heterogeneous studies

1. Selection of representative scenarios, which can be used for:

- Simplified view for policy makers
- Input to other models that require low-dimensional data (e.g. large economic-wide models with many other data inputs, to keep model sizes small, or stochastic scenario generation)

2. Removal of "superfluous" scenarios: "Is a scenario(-result) "inside" other scenarios?"

3. Quantify extremality of a scenario result "Does a new scenario add variety?"



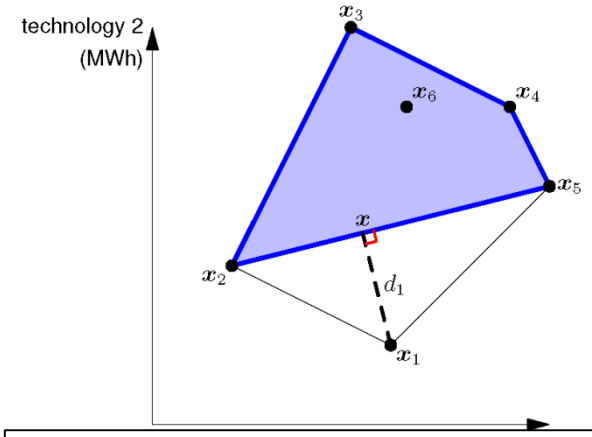
Year 2050 has relatively low annual imports across scenarios (more imports in year 2030; see report)

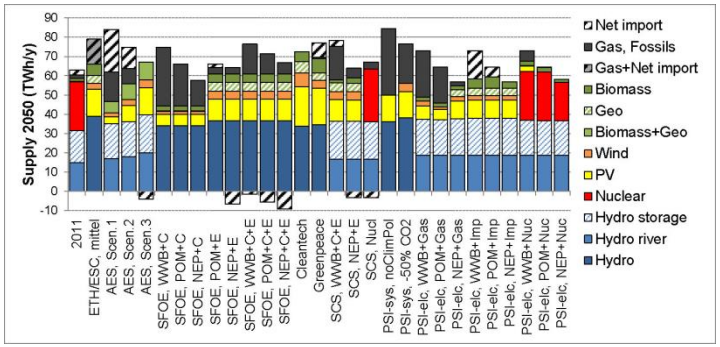
M. Densing, S. Hirschberg (2015): ***Review of Swiss Electricity Scenarios 2050***

Meta-Analysis with a Distance Measure

Distance of a scenario to the other scenarios

Example for a supply mix of only 2 technologies:





- d_1 = Distance of scenario x_1 to convex hull of all other scenarios
- Scenario x_6 can be represented as a convex combination of other scenarios (d_6 = 0)

Minimal set of representative Scenarios:

- BFE WWB + C: business-as usual scenario with new gas plants
- BFE POM + E: renewable scenario with relatively low demand
- PSI-elc, WWB + Nuc: scenario with new nuclear plants and relatively low demand

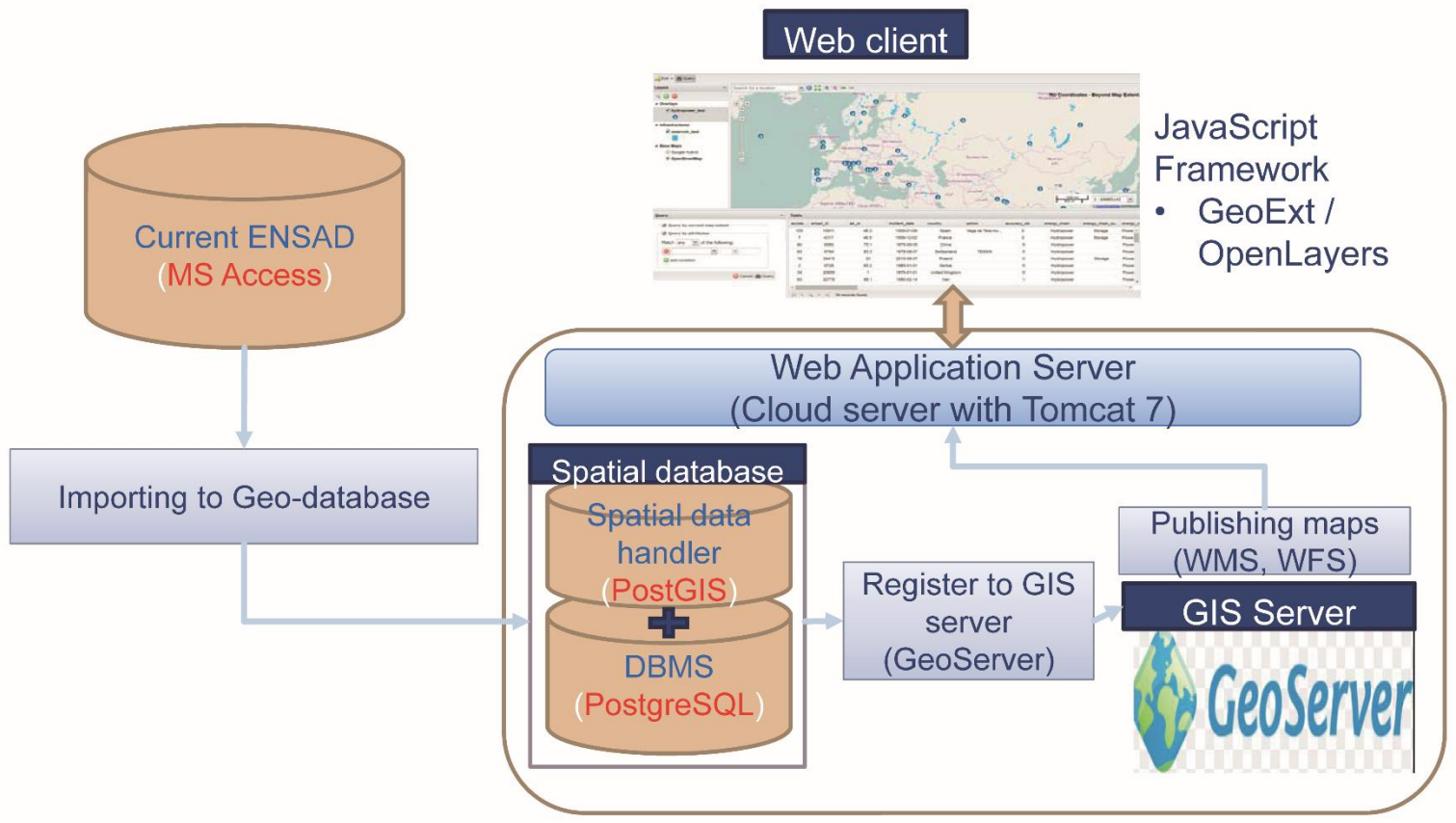
→The three representative scenarios can be interpreted as major, opposite directions of energy policies in Switzerland.

ply mix of BFE's scenario
M+C (Political measures +
ral gas-powered plant) is a
ect convex combination of
r scenarios
Possible modelling issue
cenario may be considered
uperfluous

M. Densing, E. Panos & S. Hirschberg (2016): Meta-analysis of energy scenario studies: Example of electricity scenarios for Switzerland**,** *The Energy Journal, 109*, 998-1015

Energy-Related Severe Accident Database

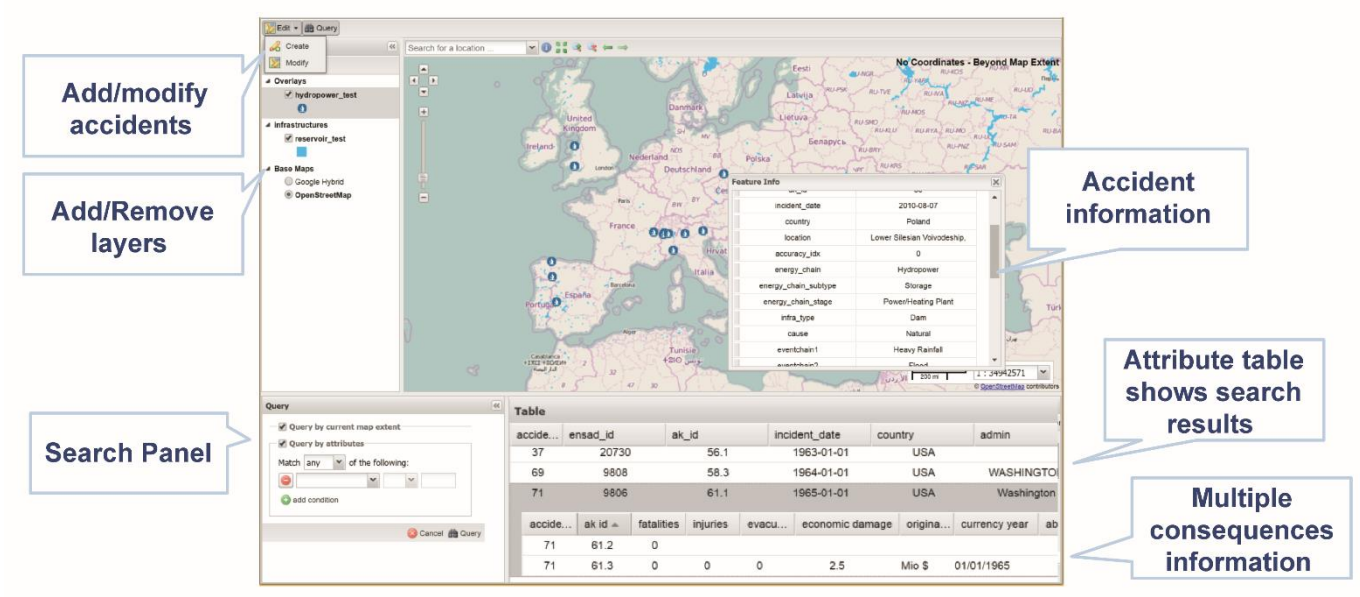
- **First release of ENSAD by PSI in 1998.**
- **Current version is relational database, using Microsoft Access.**
- **New, interactive, GIS-based ENSAD v2.0.**
- **Prototype for hydropower accidents.**



(Wansub et al., 2016)

Current Status of ENSAD v2.0

Desktop Version

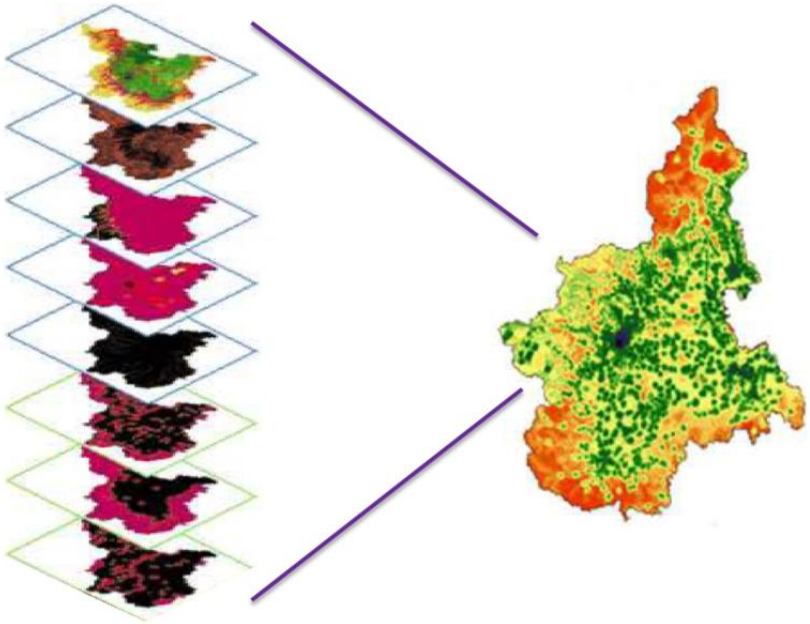


Mobile Version

(Wansub et al., 2016)

Spatial MCDA: A Case Study for Deep Geothermal Energy Systems

- The aim of this study is to combine spatial information from both explicit data (e.g., heat flow) and calculated ones (e.g., risk indicators, environmental impact indicators, etc.) for specific *a priori* defined capacity plants in Spatial MCDA for deep geothermal energy systems for Switzerland.
- A preliminary assessment (using hypothetical stakeholder profiles) for Spatial MCDA, including the presentation of a GIS type tool is under development.



On the left are the criteria maps and on the right the overall final map (Ferretti & Montibeller, 2016)

Potentials, costs and environmental assessment of electricity generation technologies

current status – preliminary results

Stefan Hirschberg et al.

People involved

Contributors: PSI (ETHZ, EPFL)

Reviewers: BFE & academia

Background, objectives and approach

Funded by: SFOE and SCCER SoE

Additional contributions from: SCCER Biosweet

To be used by:

- «Energieperspektiven 2017»
- SFOE technology monitoring

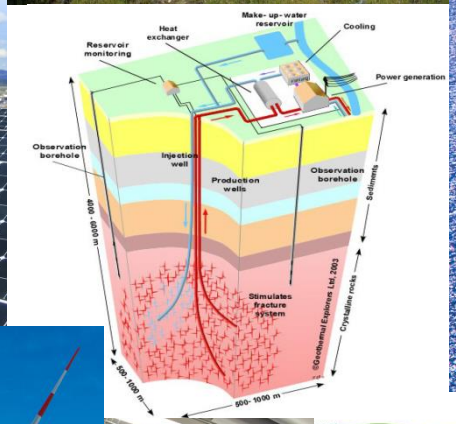
Objectives: consistent evaluation of technical potentials, costs and environmental impacts of electricity generation technologies potentially relevant for Swiss supply until 2050

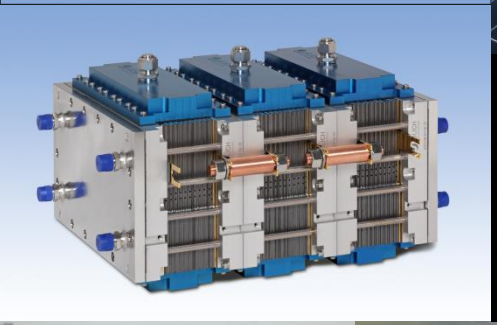
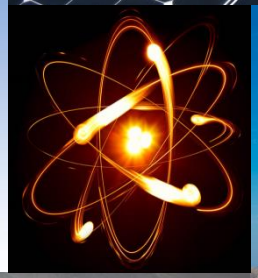
Approach:

- Major extension, updates and improvements of earlier report for SoE (Hirschberg et al., 2005)
- Literature reviews and own estimates
- Life Cycle Costs
- Life Cycle Assessment of environmental impacts
- Explicit representation of uncertainties
- Extensive review process







Make- up- water reservoir
Heat exchanger
Cooling
Reservoir monitoring
Power generation
Observation borehole
Injection well
Production wells
Observation borehole
Sediments
400- 600 m
Stimulates fracture system
Crystalline rocks
500- 1000 m
500- 1000 m
©Geothermal Explorers Ltd. 2003

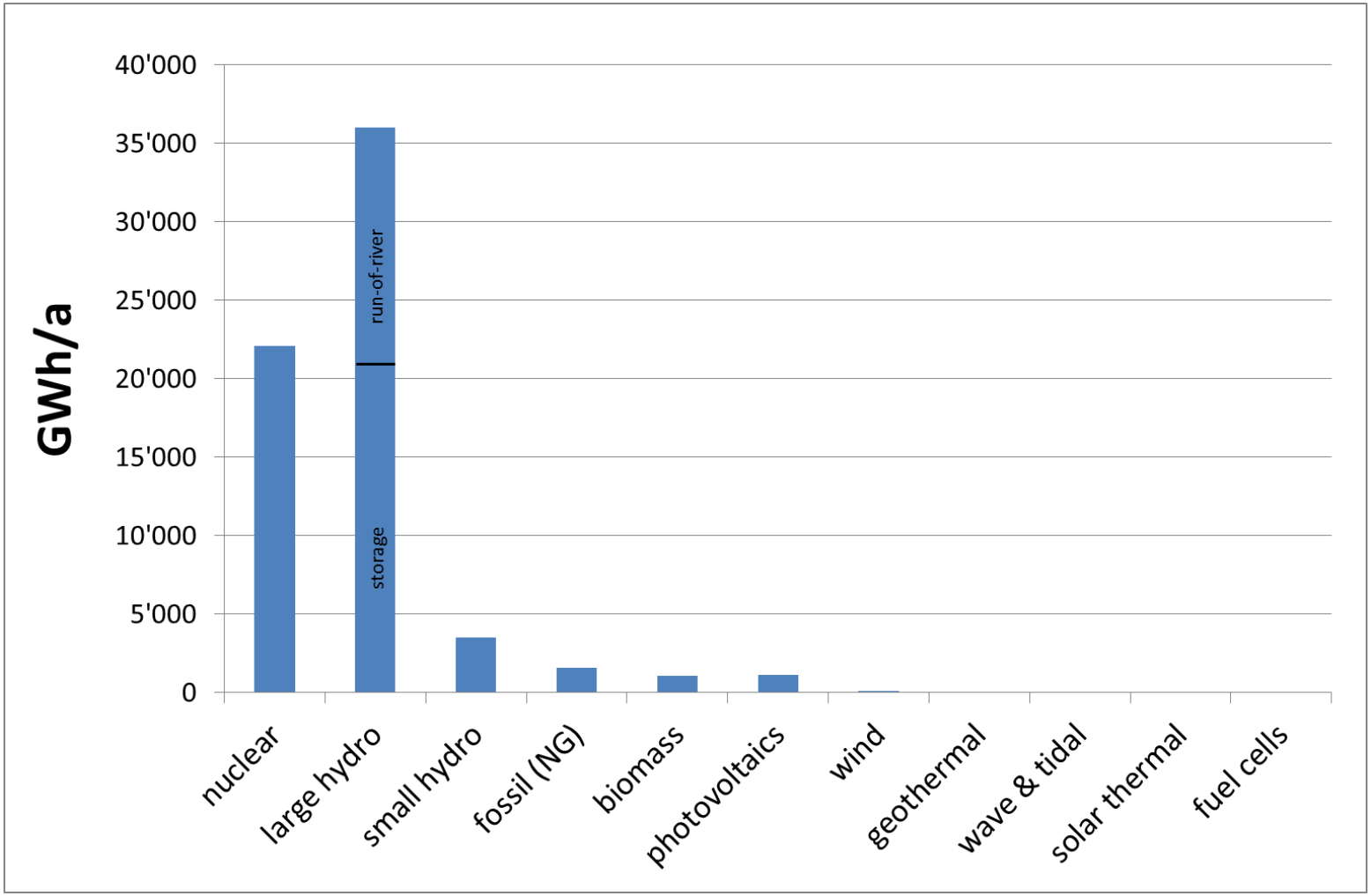










Technical potentials: Current generation (2015)

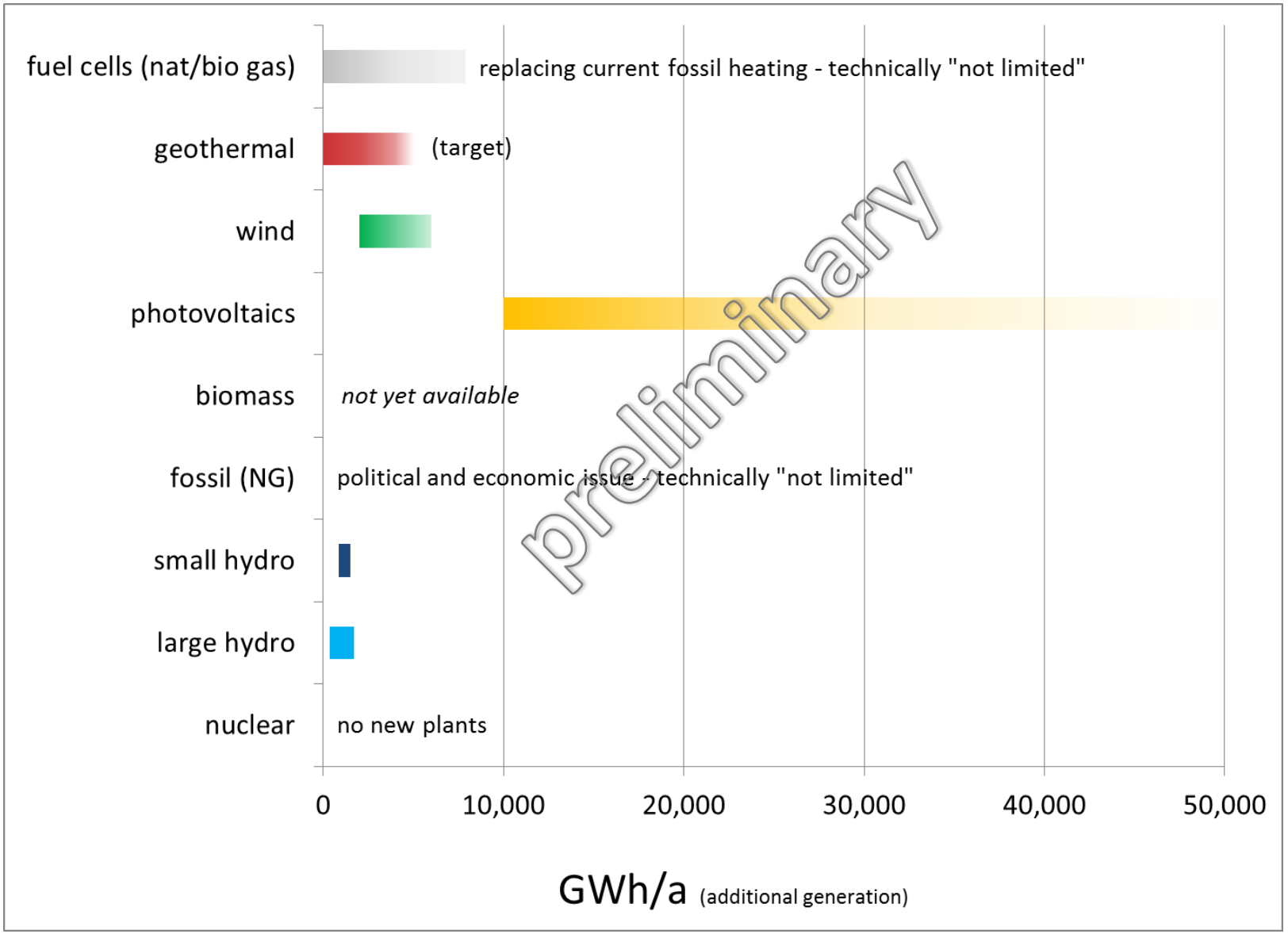


Sources:

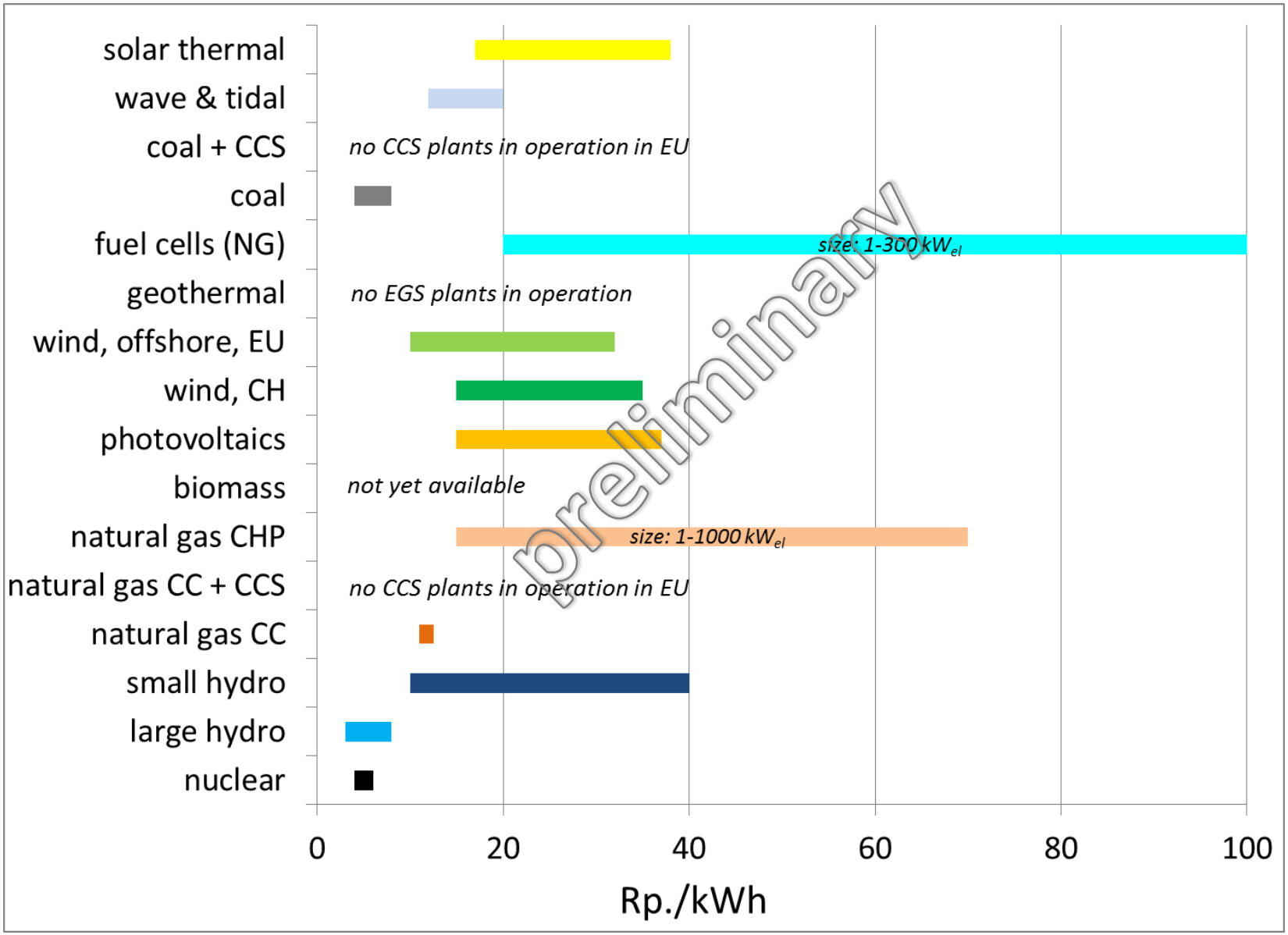
BFE Elektrizitätsstatistik 2015

Schweizerische Statistik der erneuerbaren Energien 2015

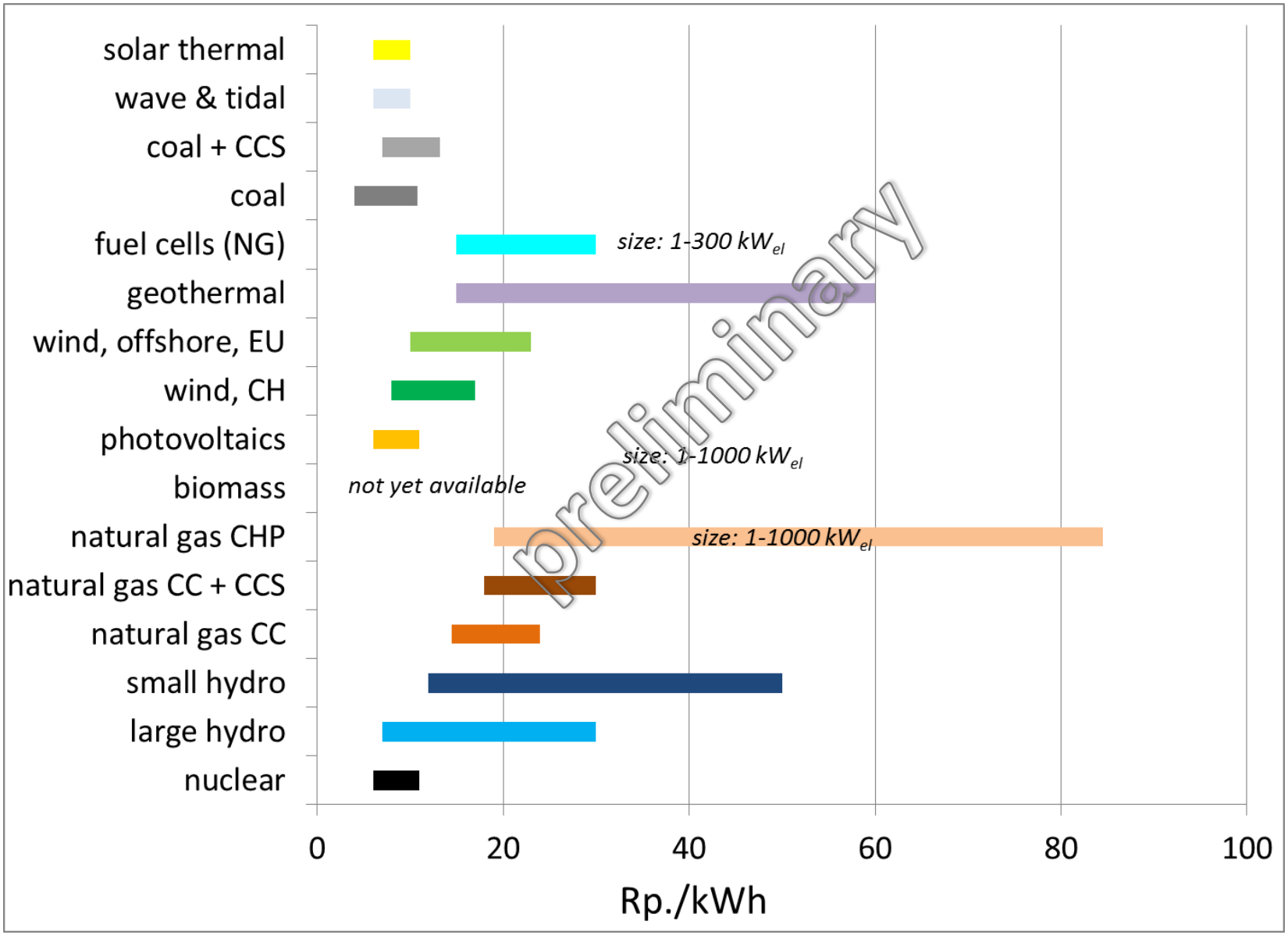
Technical potentials:
Future additional generation (until 2050)



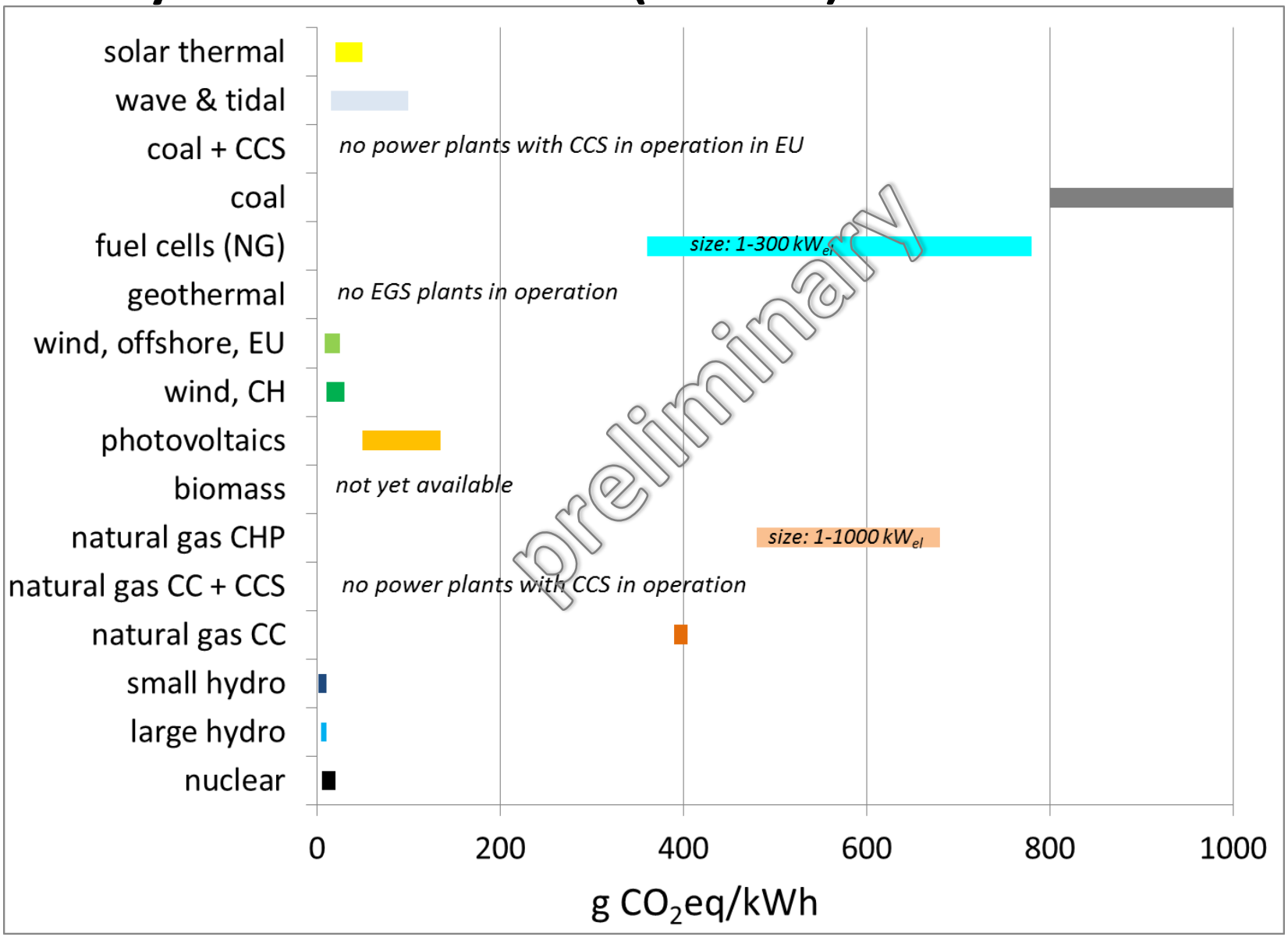
Costs: current generation



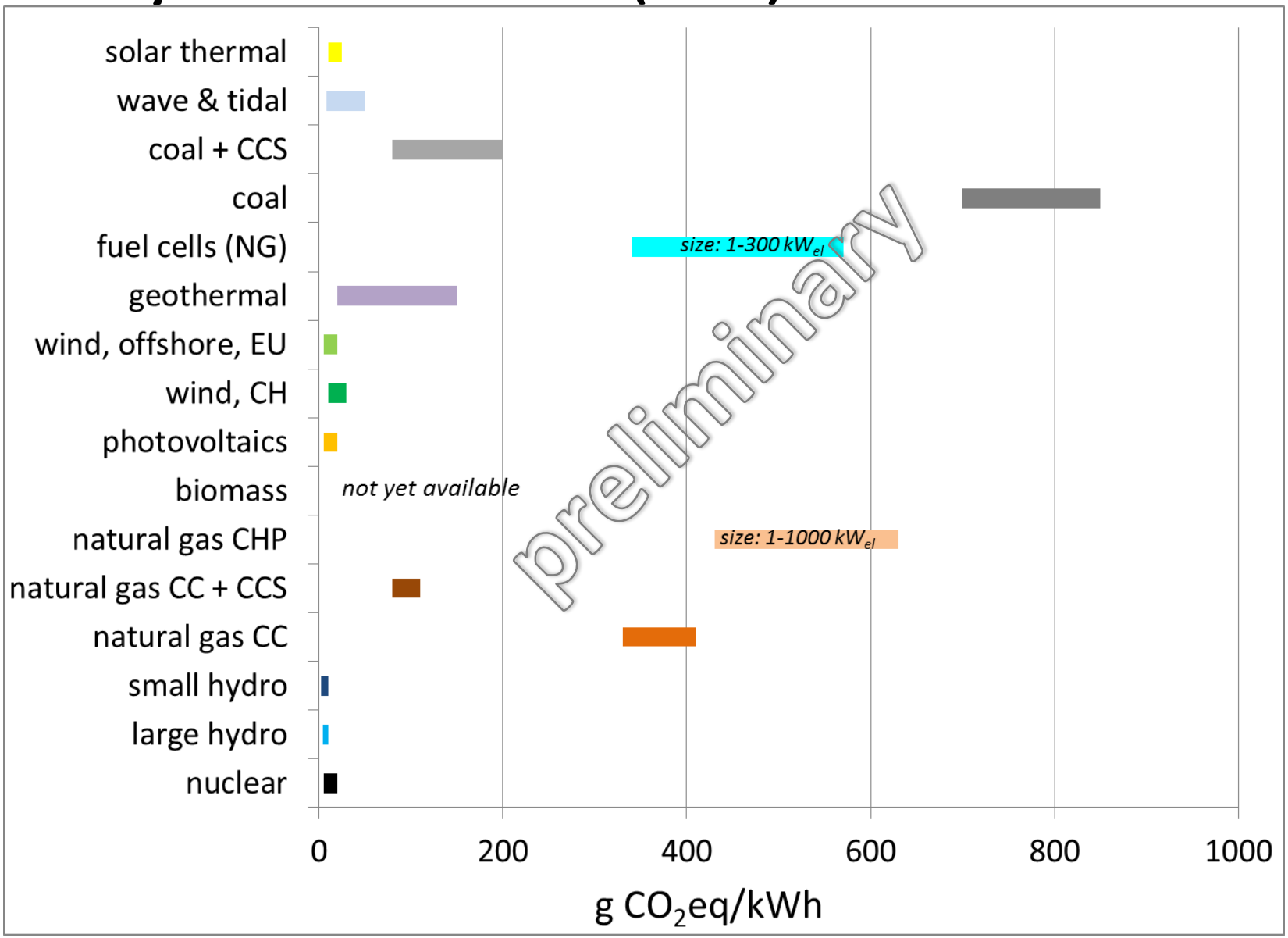
Costs: future generation (2050)



Environmental aspects:
Life-cycle GHG emissions (current)



Environmental aspects:
Life-cycle GHG emissions (2050)



Conclusions & outlook

- Broad spectrum of technologies analyzed including prospective advancements
- Major scope extensions, updates and methodological improvements compared to earlier analyses
- Large uncertainties particularly for immature technologies
- Further consolidation of cross-cutting issues in progress
- Comprehensive state-of-the-art report will be available before the end of 2016
- Findings to be reflected in future scenario analyses
- Analysis of storage technologies envisioned

With contributions from:

- Christian Bauer
- Yvonne Bäuerle
- Serge Biollaz
- Peter Burgherr
- Brian Cox
- Thomas Heck
- Stefan Hirschberg
- Maxim Lehnert
- Anton Meier
- Martin Saar
- Warren Schenler
- Minh Quang Tran
- Karin Treyer
- Fredi Vogel
- Christian Wieckert
- Xiaojin Zhang
- Martin Zimmermann