Designing a Sustainable Swiss Energy System

A Technological and Institutional Perspective

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Contents

Introduction

- Today's energy issues – general:
  - Finite reserves and lack of accessibility
  - Growing energy demand
  - Increasing price variability
  - Security of supply
  - Dependency on politically unstable regimes
  - Environmental degradation from resource extraction to consumption
  - Human health problems
- Today's energy issues – Switzerland in particular:
  - High import share
  - High CO2 emissions
  - Closing down of two nuclear power plants – 'electricity gap' of 25%
- Alternative solutions are needed

Characteristics of the Swiss Political System

- Sustainability is leading concept
  - Evironmental – Social – Long term economic
- Direct democracy
  - Public initiatives and referenda

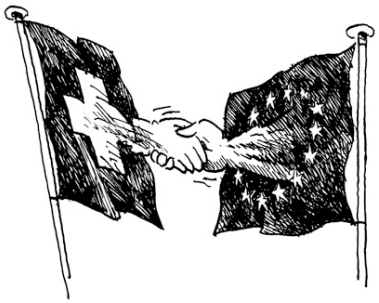
  \+ Enables population to propose or to prevent a law

  \+ Leads to compromises supported by majority

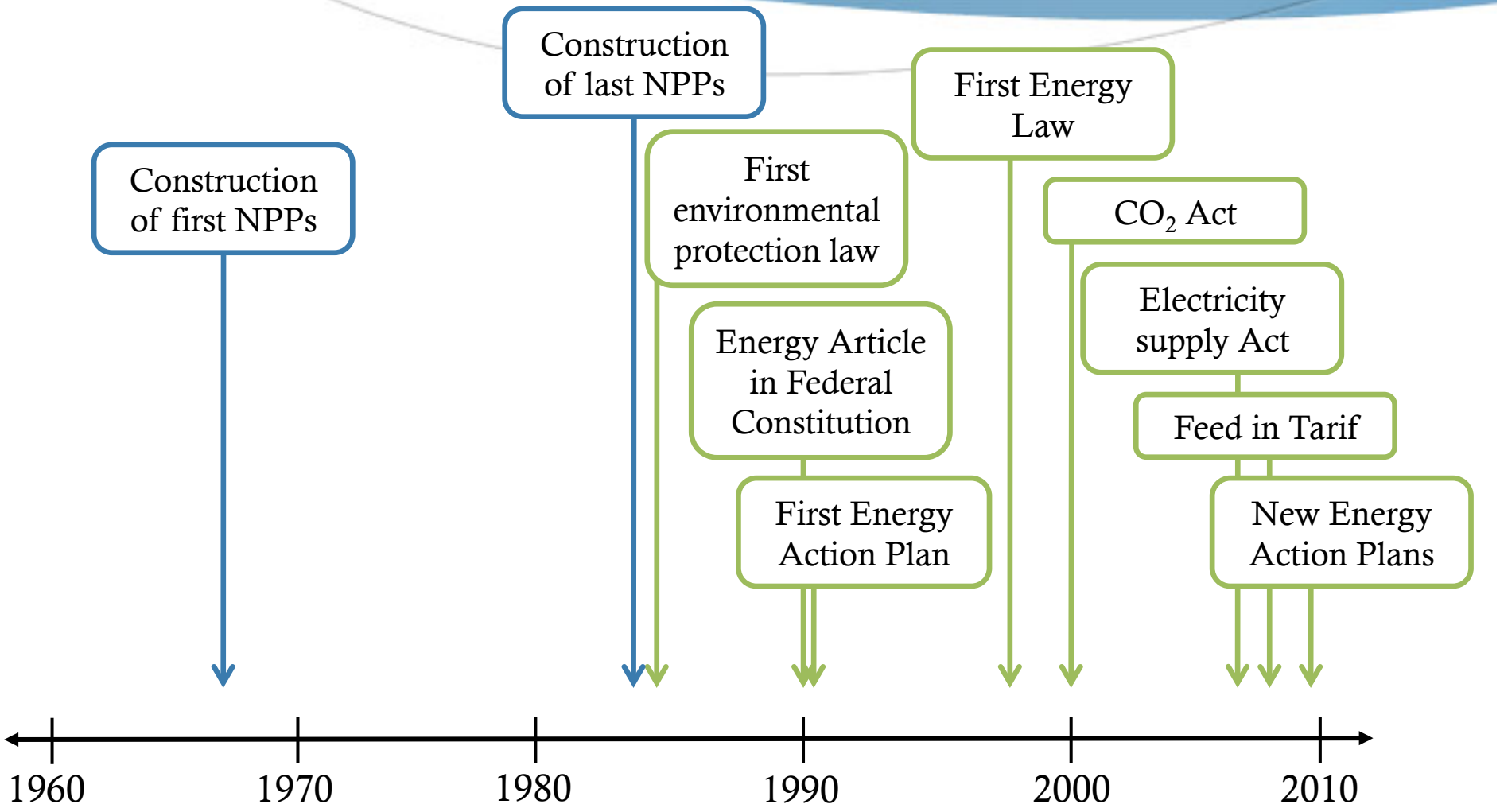
  – Can delay political process and change

  – Might hinder radical change and innovation

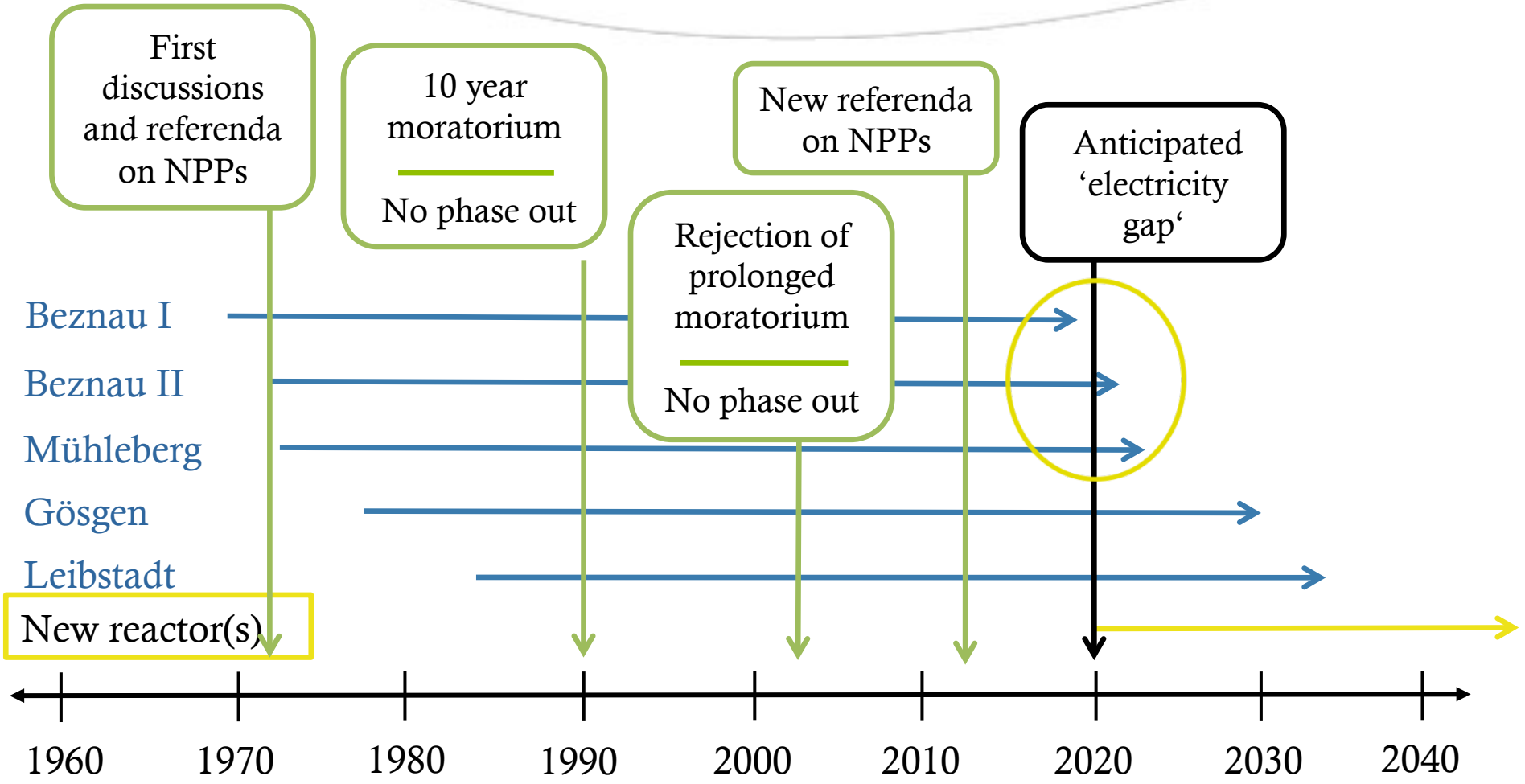
- Compliance with many EU directives
  - High integration into international energy and especially electricity trade (policies)



Important political milestones

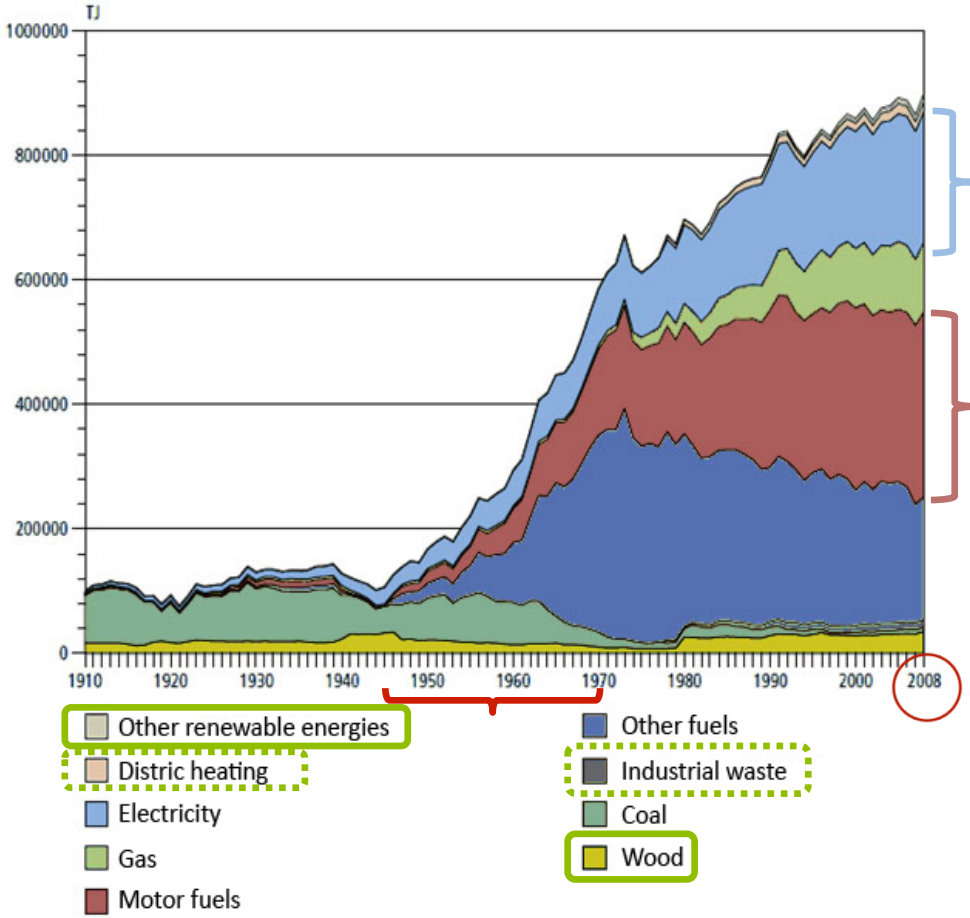


Nuclear power development

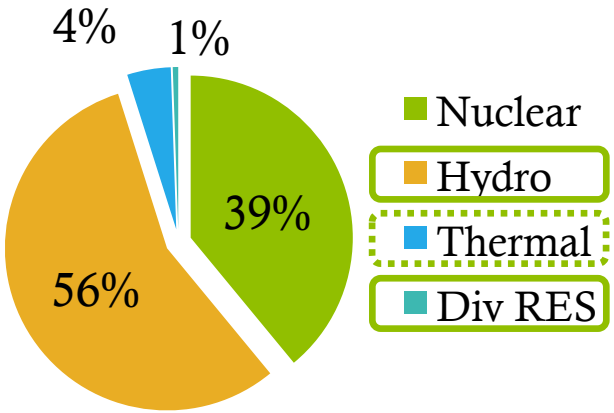


Technological Analysis

Swiss energy demand



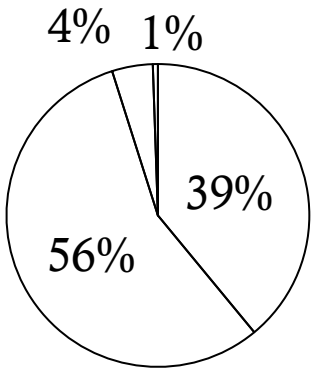
Electricity production



Road traffic 90 %

18,5 % of PES come from renewable resources

Electricity Production



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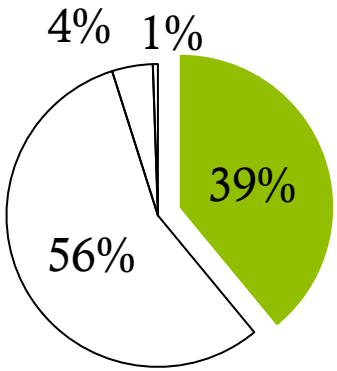
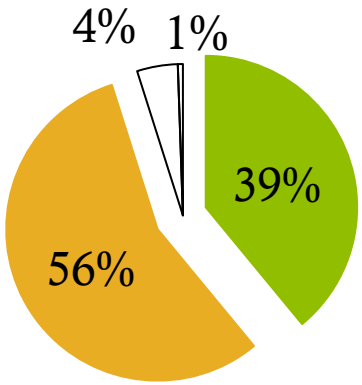


Nuclear

5 Reactors
3 Reactors supply DH

Electricity Production



Nuclear

5 Reactors
3 Reactors supply DH

Hydro

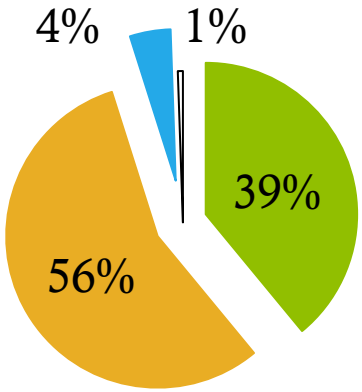
- Storage hydro
- River hydro
- Pumped storage hydro
- Micro hydro

Electricity Production

Thermal

38% of fuels is from RE

- Distric heating CHP
- Micro CHP
- Industrial CHP
- Waste incineration plants
- Electricity plant



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Electricity Production

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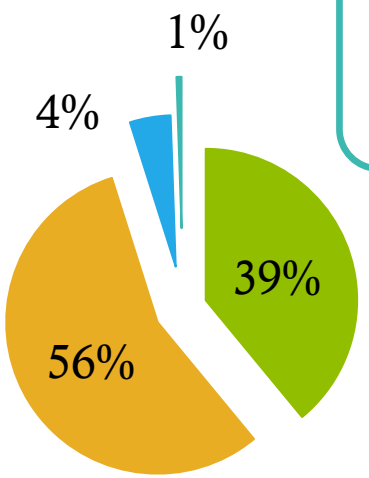
- Electricity plant

Renewable technolgies

- Photovoltaic - 44.8 MW
- Solar thermal - 377 MW
- Wind - 13.6 MW



Nuclear

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3 Reactors supply DH

Hydro

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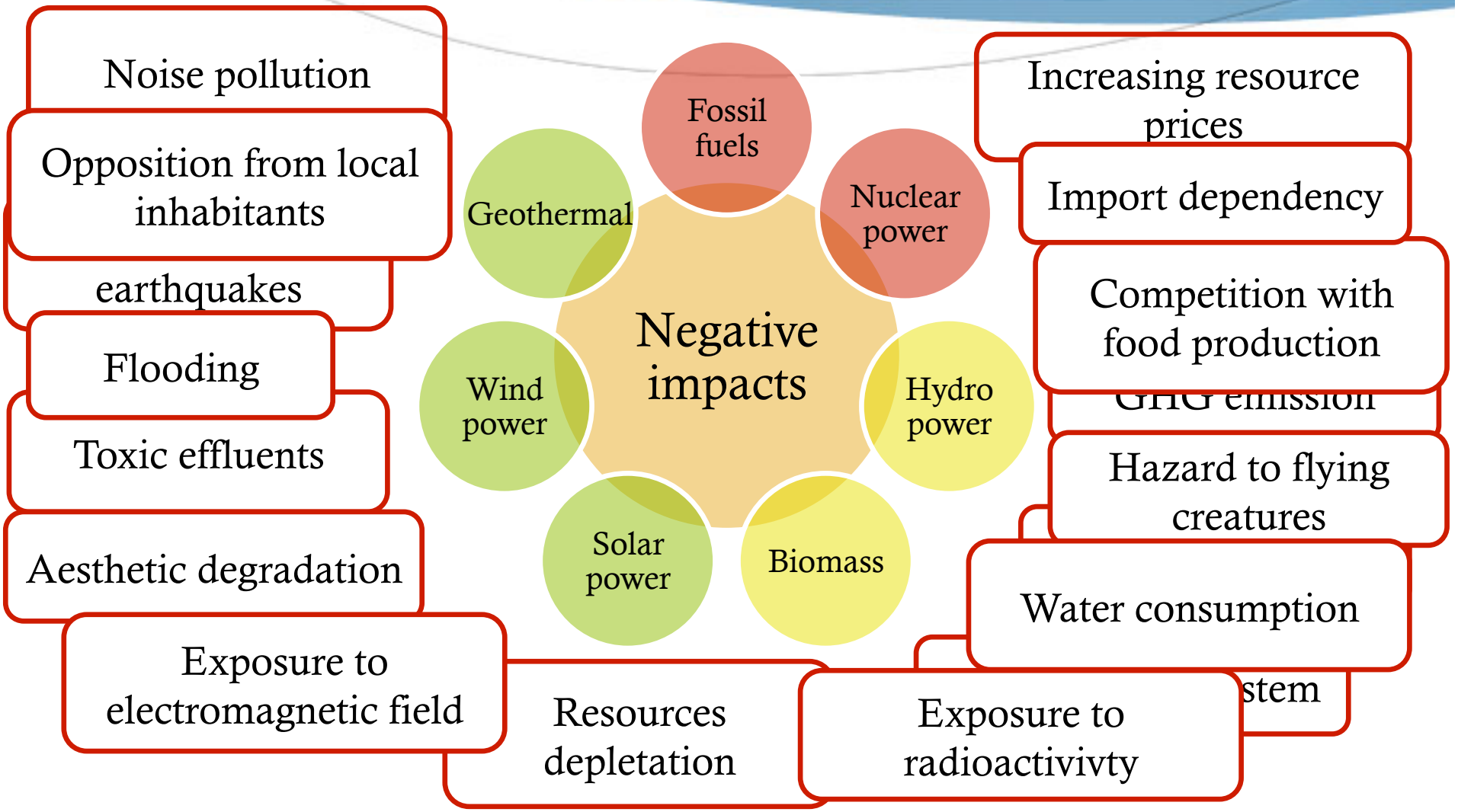
- Pumped storage hydro
- Micro hydro

Sustainability Issues



Research question

How can the Swiss energy sector be developed in a sustainable way and what is the character of the needed institutional change?

Sub-questions

1. What is the current political and technological situation of the Swiss energy sector and what are the critical issues from the perspective of sustainability?

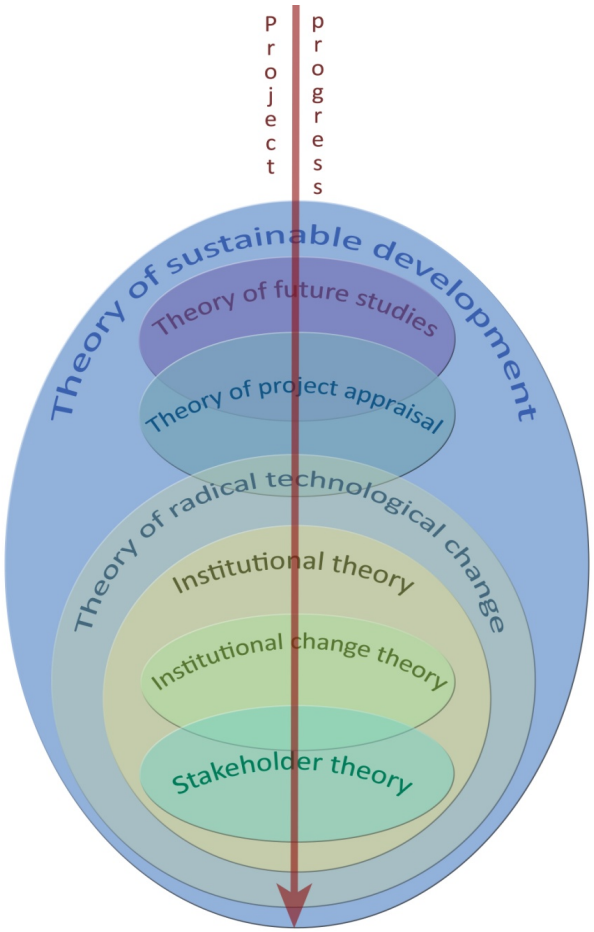
2. What is the domestic energy resource base for the choices of the future development of the Swiss energy system?

3. What is a sustainable solution for re-designing the Swiss energy system?

4. What is the character of the change necessary in the institutional setting of the Swiss energy system for implementing a sustainable alternative and what are the positions and opinions of the key stakeholders?

Methodology

Applied theories of subject

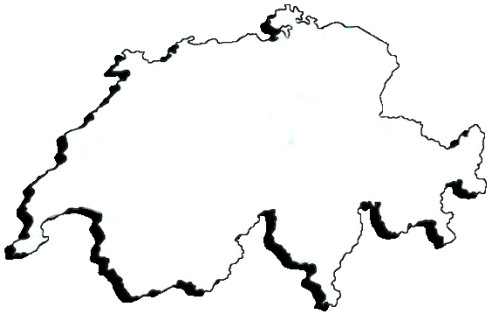


Research tools:

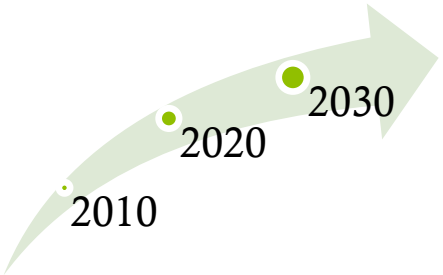
- Literature studies and document analysis
- Idealized re-design
- EnergyPLAN
- Cost-benefit analysis
- Institutional change analysis
- Stakeholder analysis
- Structured interviews

Limitations

Geographical



Time

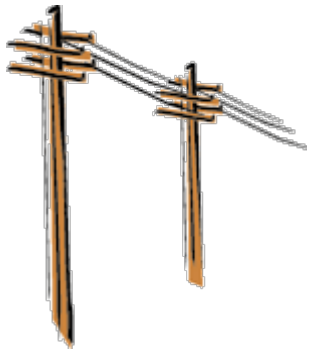


Transportation

Future technologies

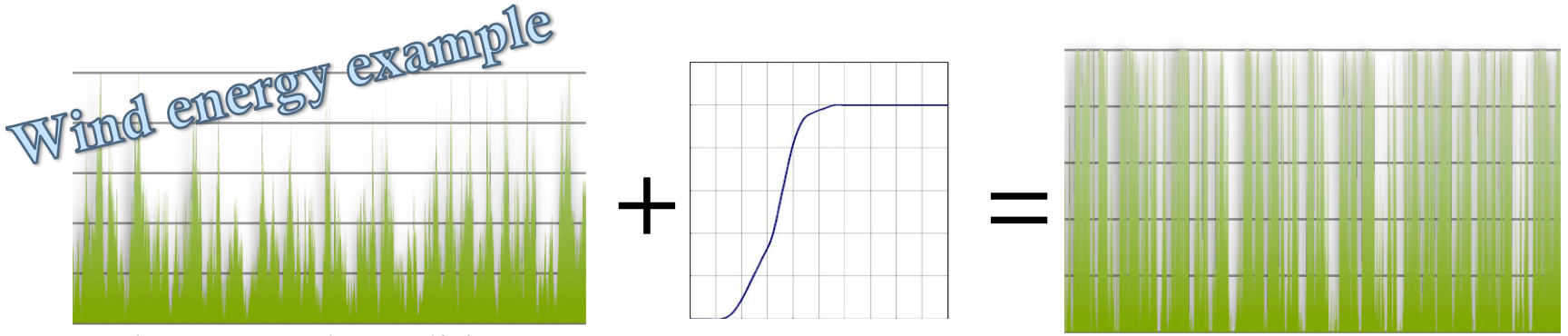
Behavioural change

Grid



Modelling the current system

- The modelling tool - EnergyPLAN
- 159 data inputs, out of which 69 % from sources, 16% calculated from statistical data, 15% assumptions.
- 11 self-made hourly fluctuation data files for hydropower, solar PV, SC, wind power as well as electricity and heat demand.



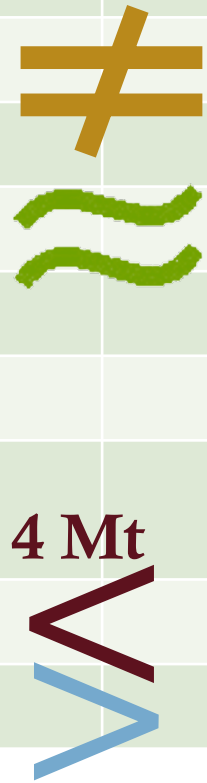
The external conditions

Technological specifications

The hourly production fluctuations

Validation of the modelled system

	Existing System 2008	Modelled System 2008
Electricity Demand	58.70	58.70
Import (TWh)	50.27	4.62
Export (TWh)	51.41	5.45
Trade Balance (TWh)	1.14	0.83
RES		
Share of PES	18.50%	18.80%
Share of electricity production	58%	62%
CO_2 Emissions (Mt)	42.2 (2007)	46.1
Fossil Fuel Use (TWh)	183.1	172.6



Modelling of Future Pathways

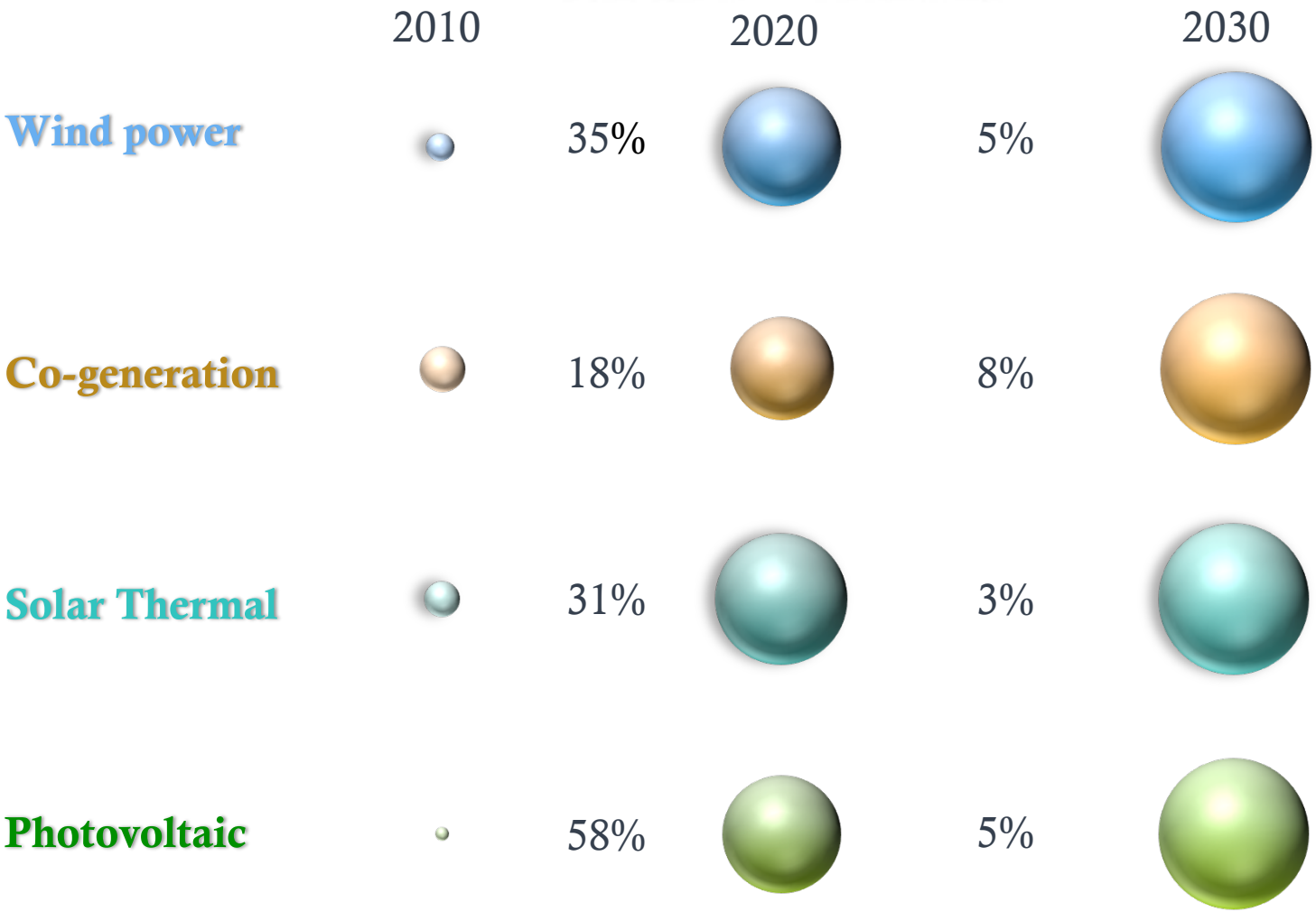
Business-as-usual (BAU) | **Alternative pathway (AP)**

- Projected growing trends in energy and fuel demand
- Projected historical development of the existing technologies

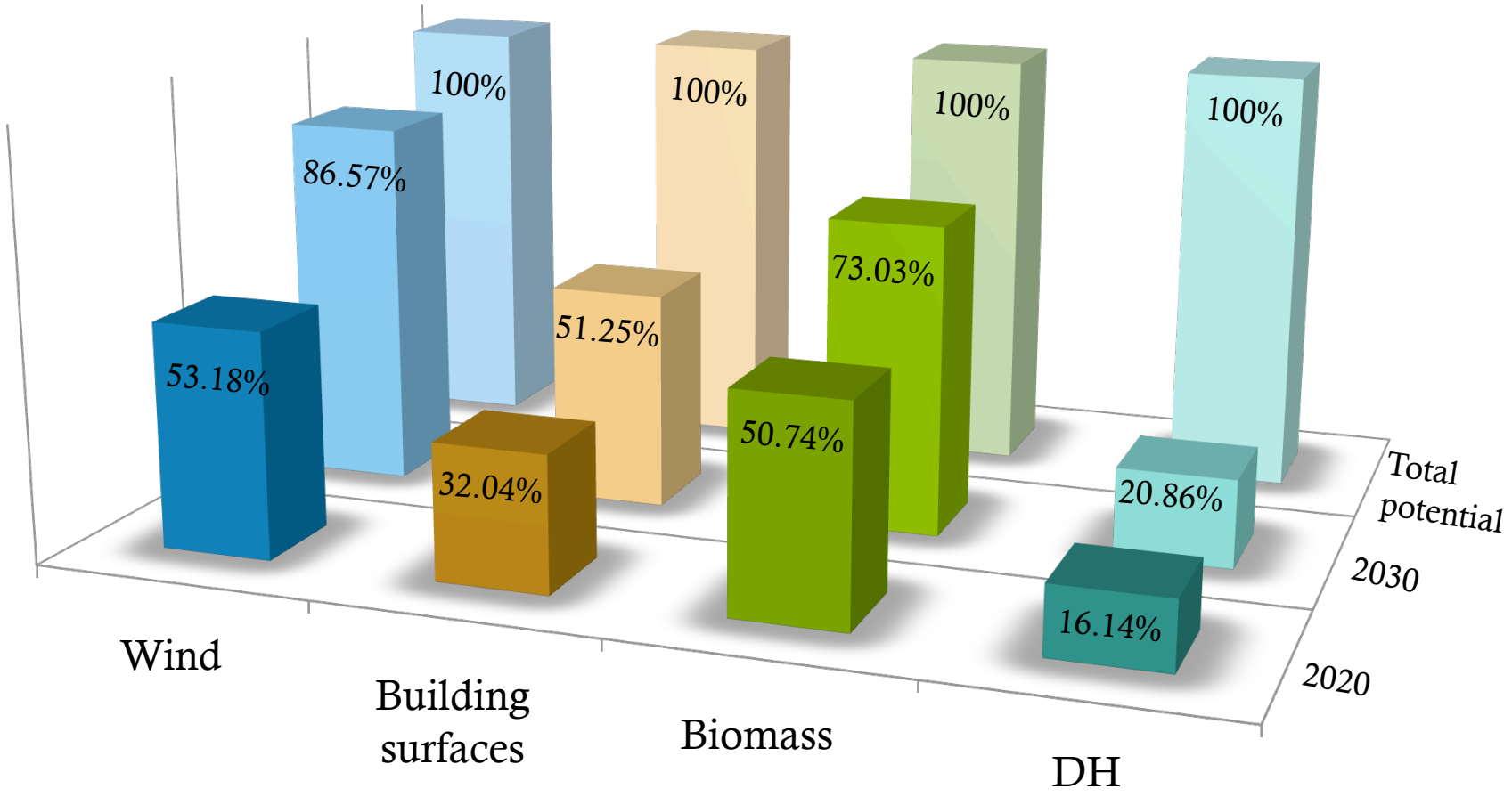
- New nuclear capacity
- Estimated EV sales

- Accelerated development of RE capacities
- Increased EV sales
- Phase out individual coal boiler
- Partially replace individual heating with solar collectors and district heating

Yearly Growth Rates in AP



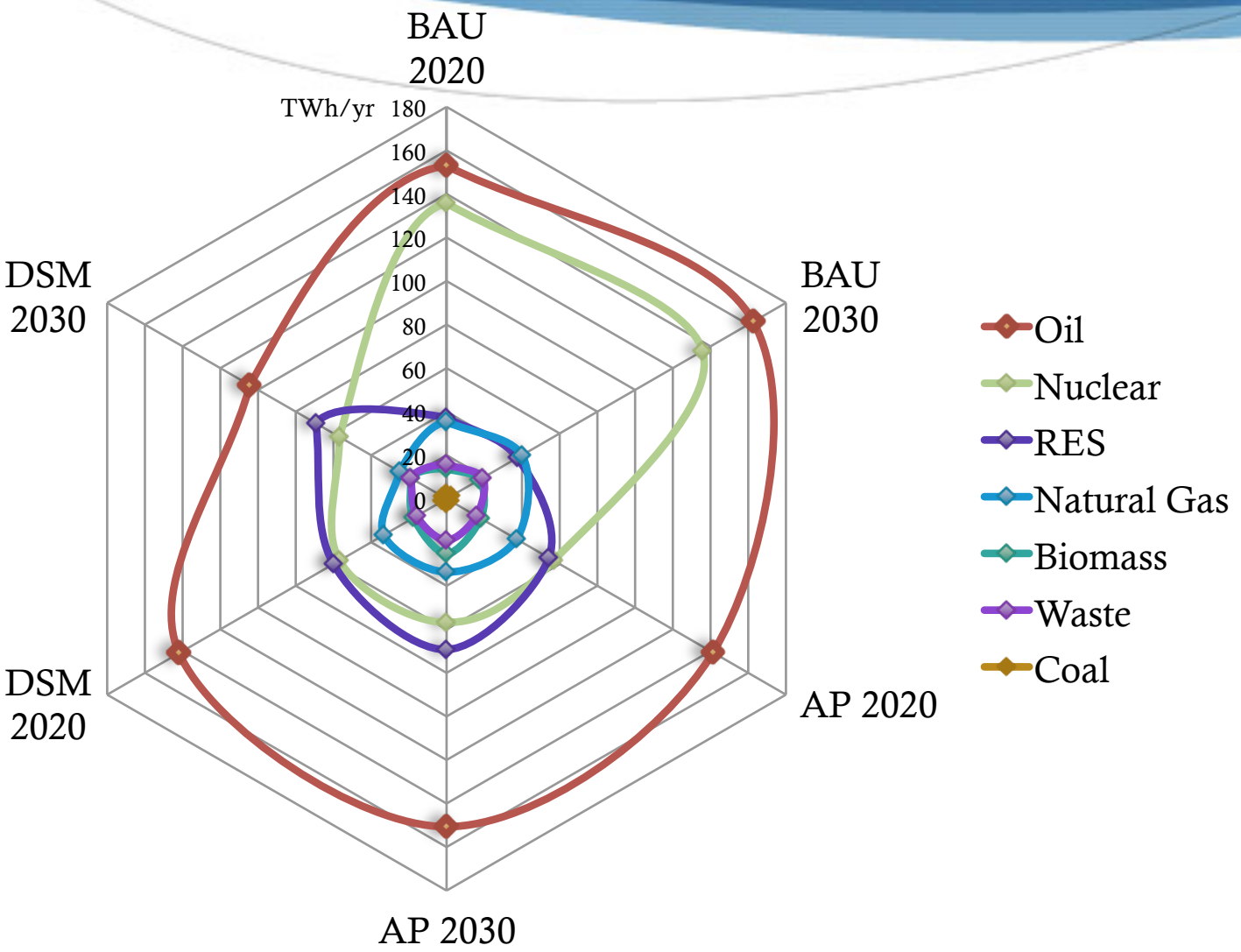
Utilization of Resources



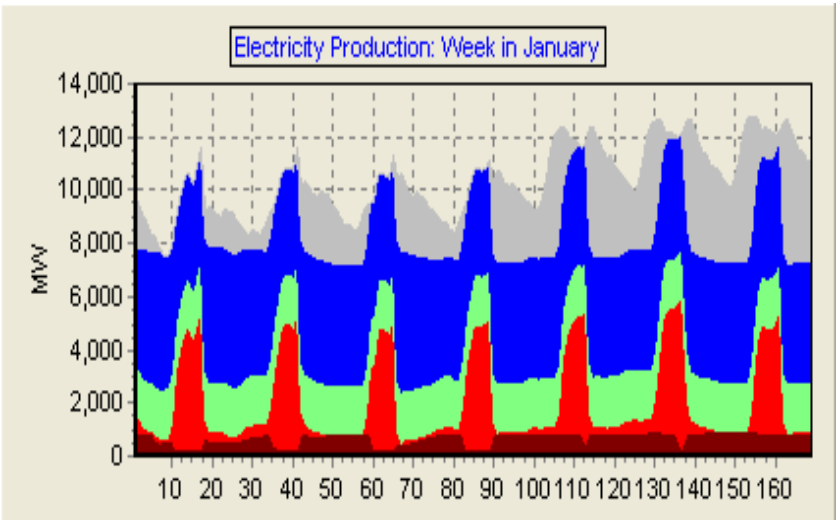
Demand Side Management (2020 - 2030)

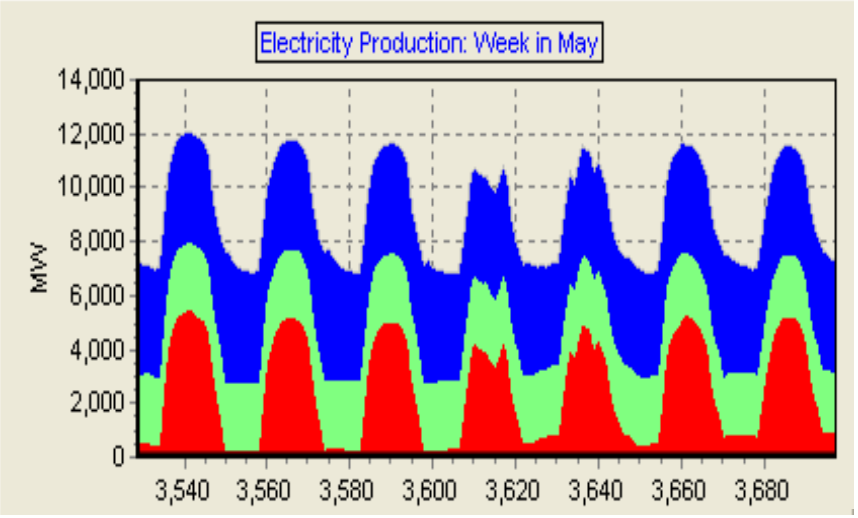
- Electricity demand (based on 2020) -15%
- Industry & services fuels (based on 2020) -15%
- Transportation fuels (based on 2020) -15%
- Electric Heating ✖
- Residential Oil Boilers ✖

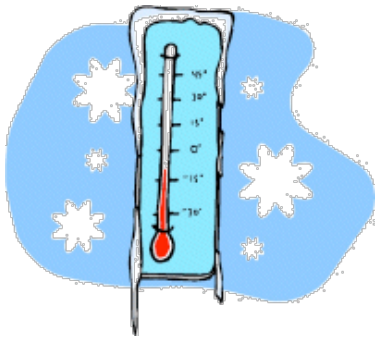
Comparison of pathways



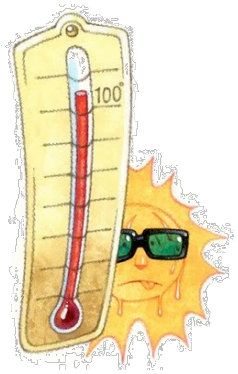
Demand & Supply Balance (AP)







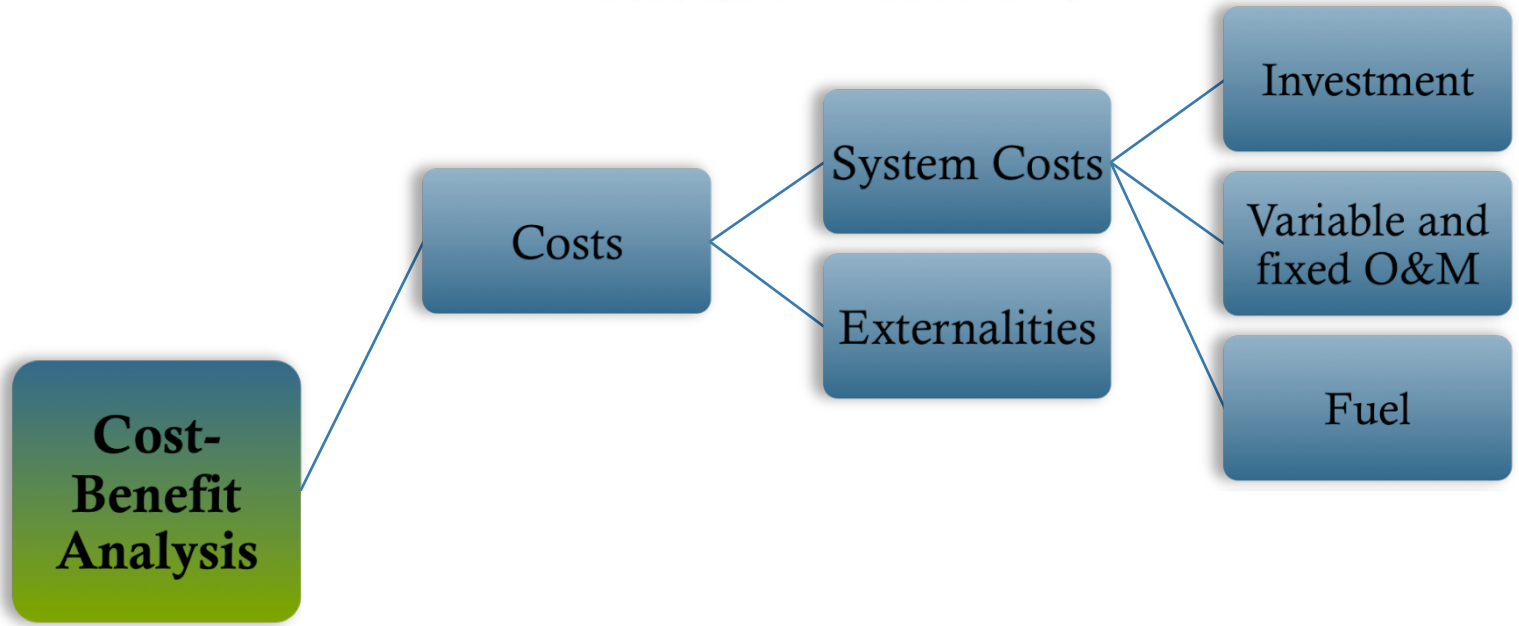
- Electricity demand
- Electricity export
- Electricity import
- Nuclear+ Power plants+ Storage Hydro
- River Hydro
- Wind and PV
- Co-generation



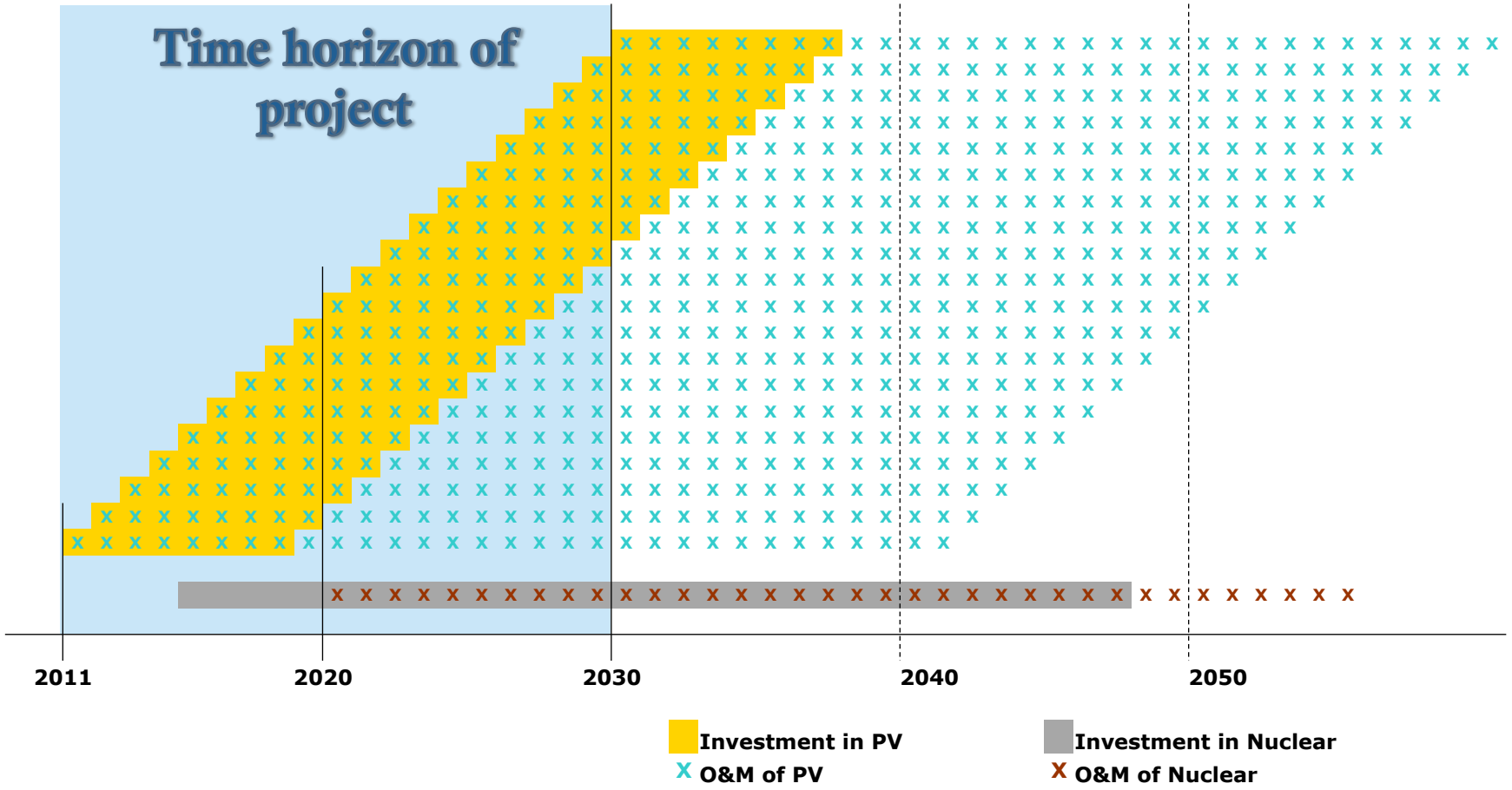
Cost & Benefit Analysis

Nuclear Power	Renewable technologies
- Long lifetime and payback period - High O&M costs - Medium fuel costs - High investment costs - Highly dependent on imports	- Various lifetimes and payback periods - Low O&M costs - Low/no fuel costs - High investment costs - Local value creation

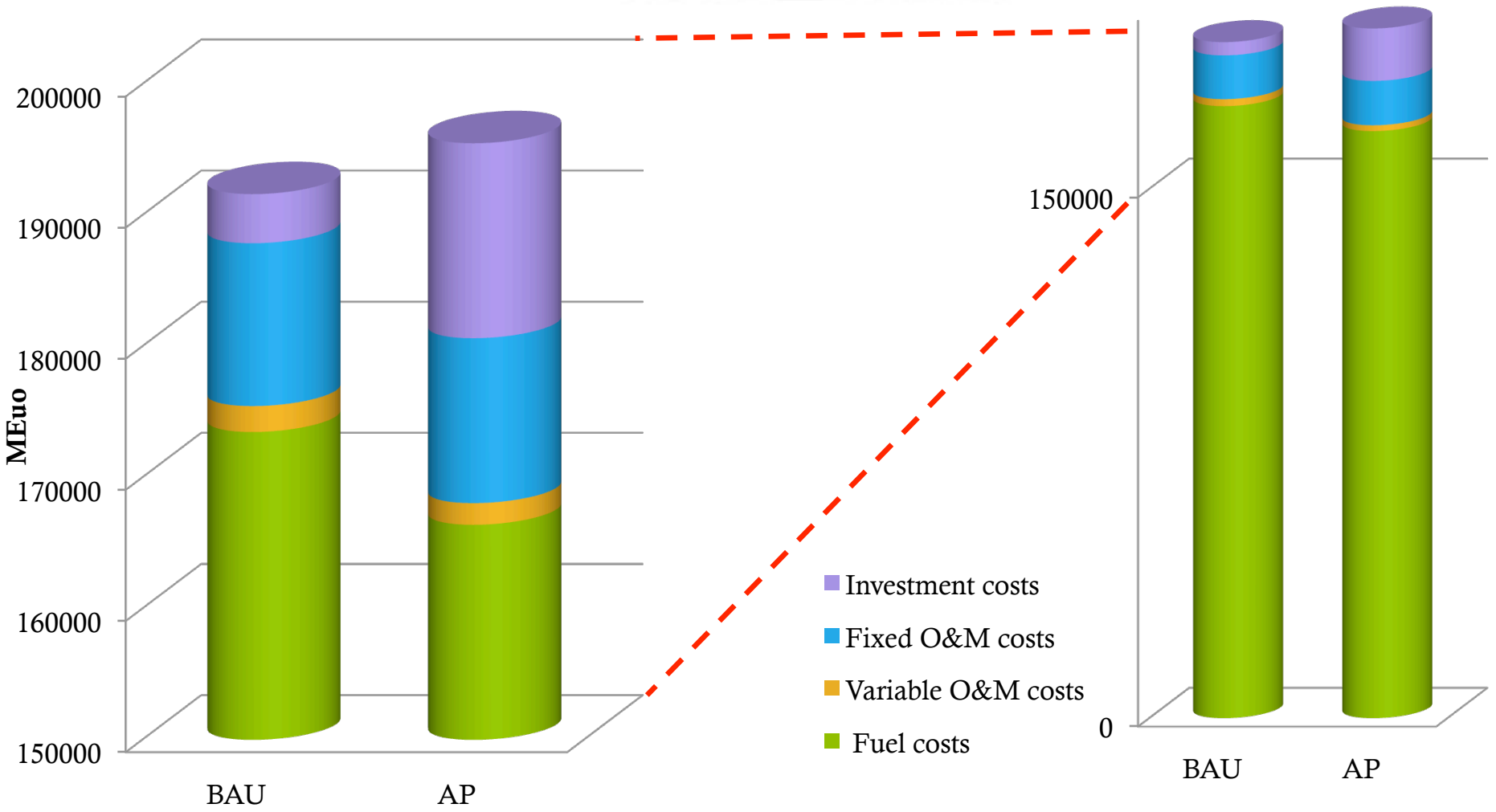
Structure of Costs & Benefits



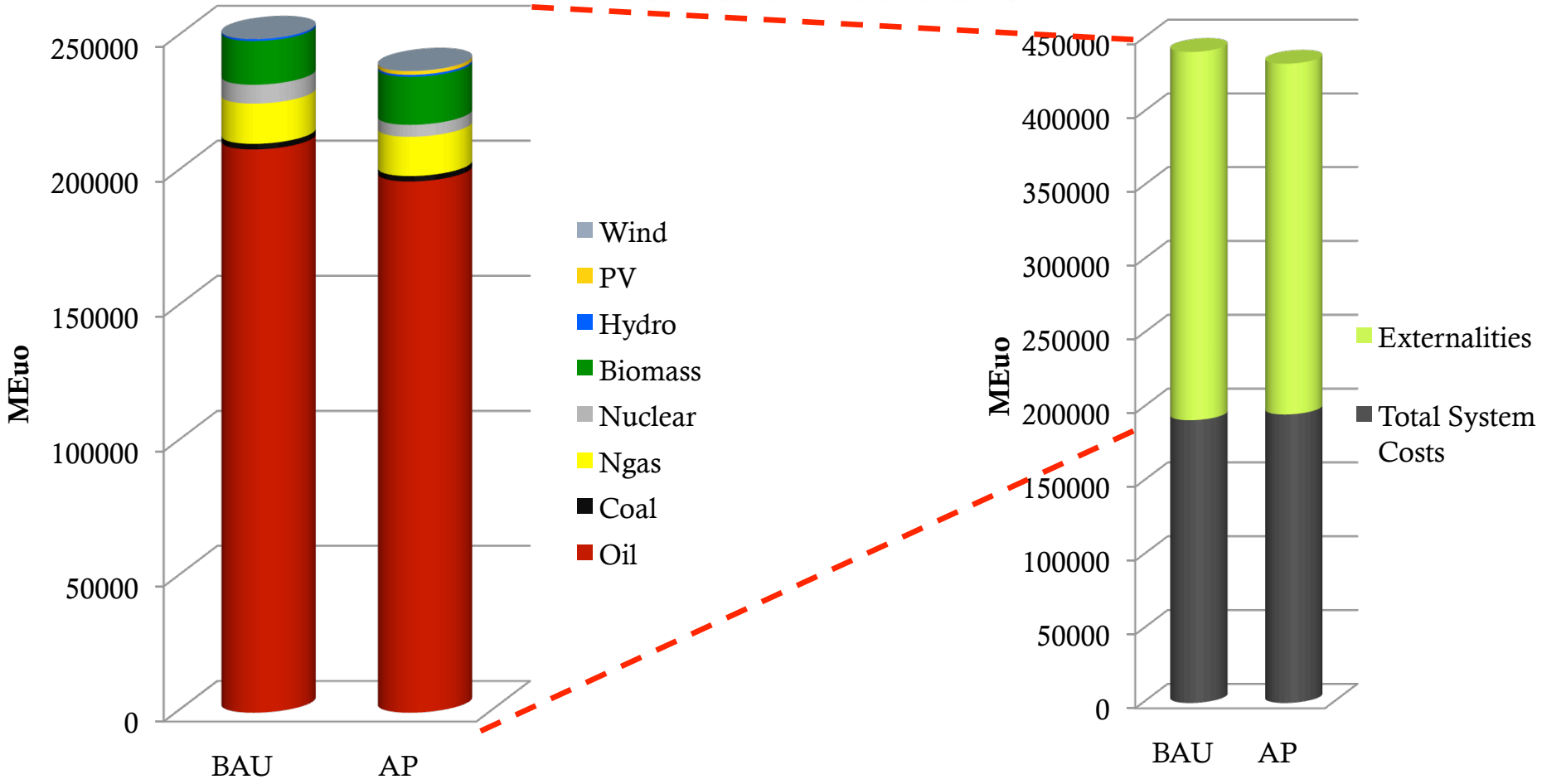
Methodology of Cost Calculations



Total System Costs



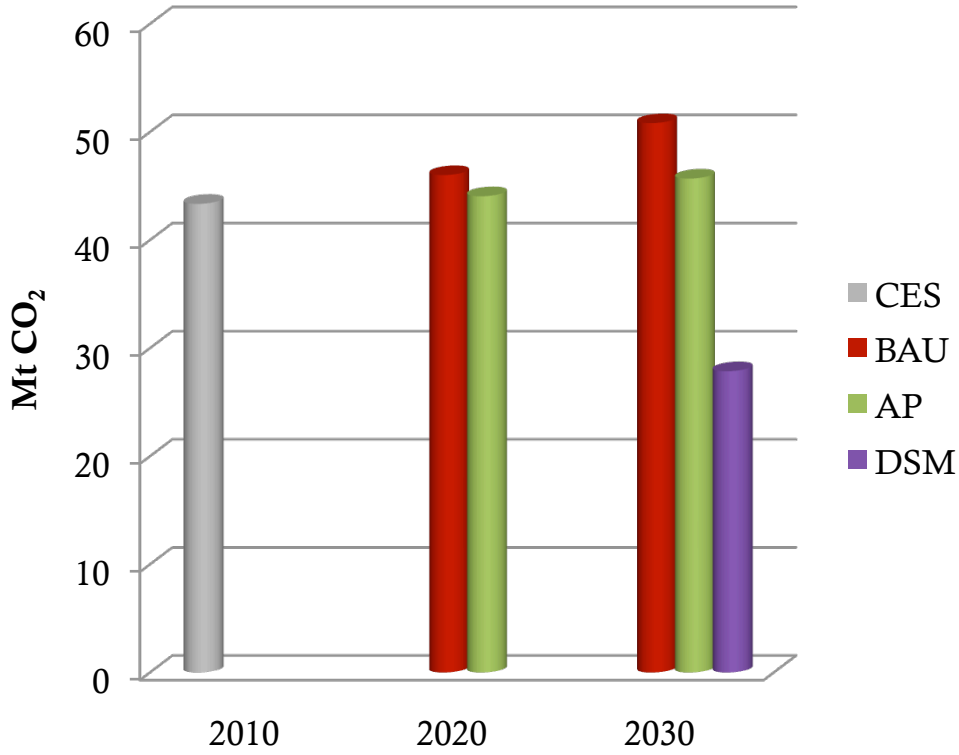
Externalities



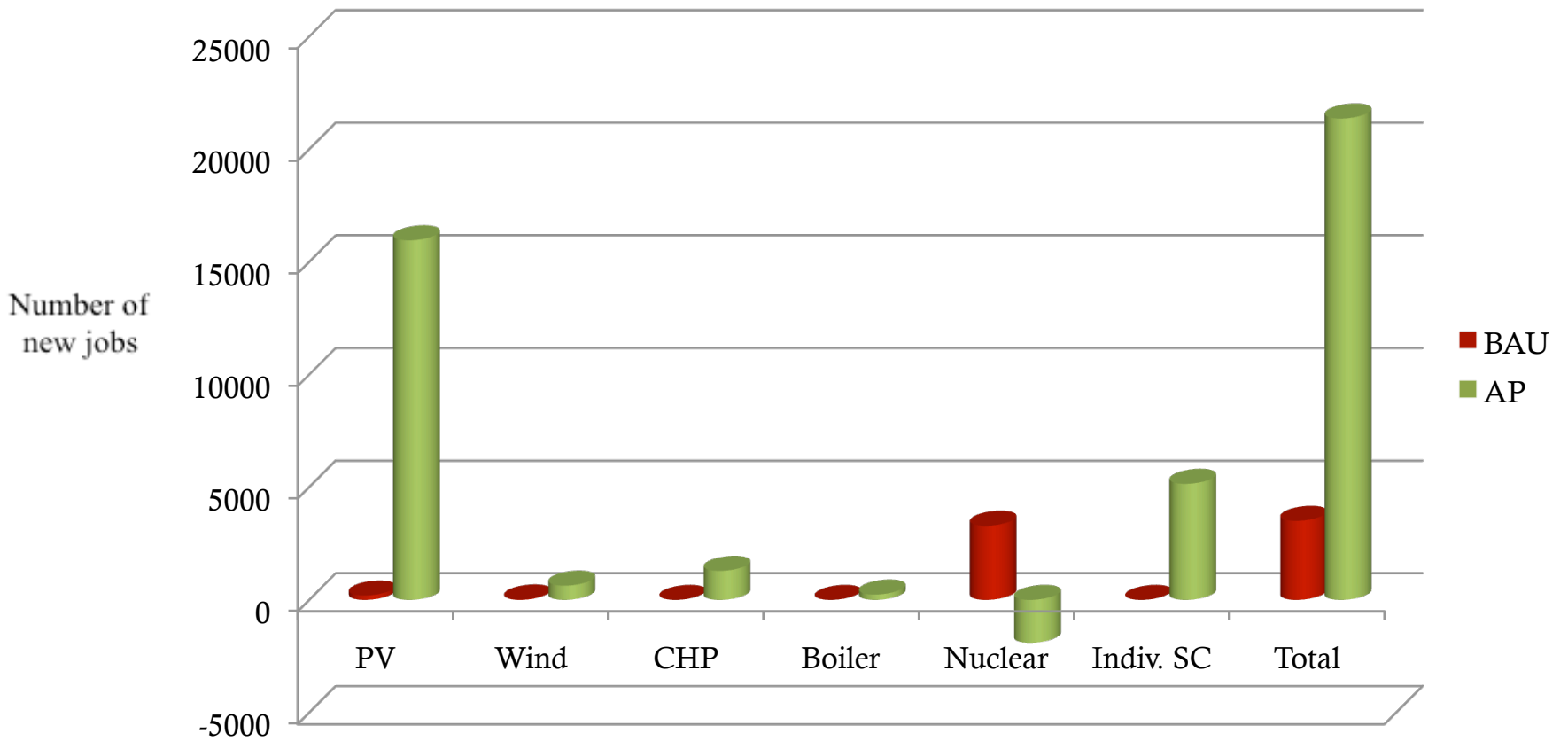
Benefits

Shifting expenses from fuels and investments in nuclear reactors to investment in renewables leads to:

- Reduced CO_2 emissions
- Reduced dependency on imports and domestic value creation
- Employment



Benefits - Employment



Additional Benefits - DSM

24.2 TWh/yr theoretical excess electricity production

- → Decommissioning of all remaining nuclear power (18.8 TWh/yr) can be considered
- → Reduced investments in renewable production possible (lower growth rates)
- → Electricity-to-fuel conversion (further benefits such as CO_2 / import reductions)

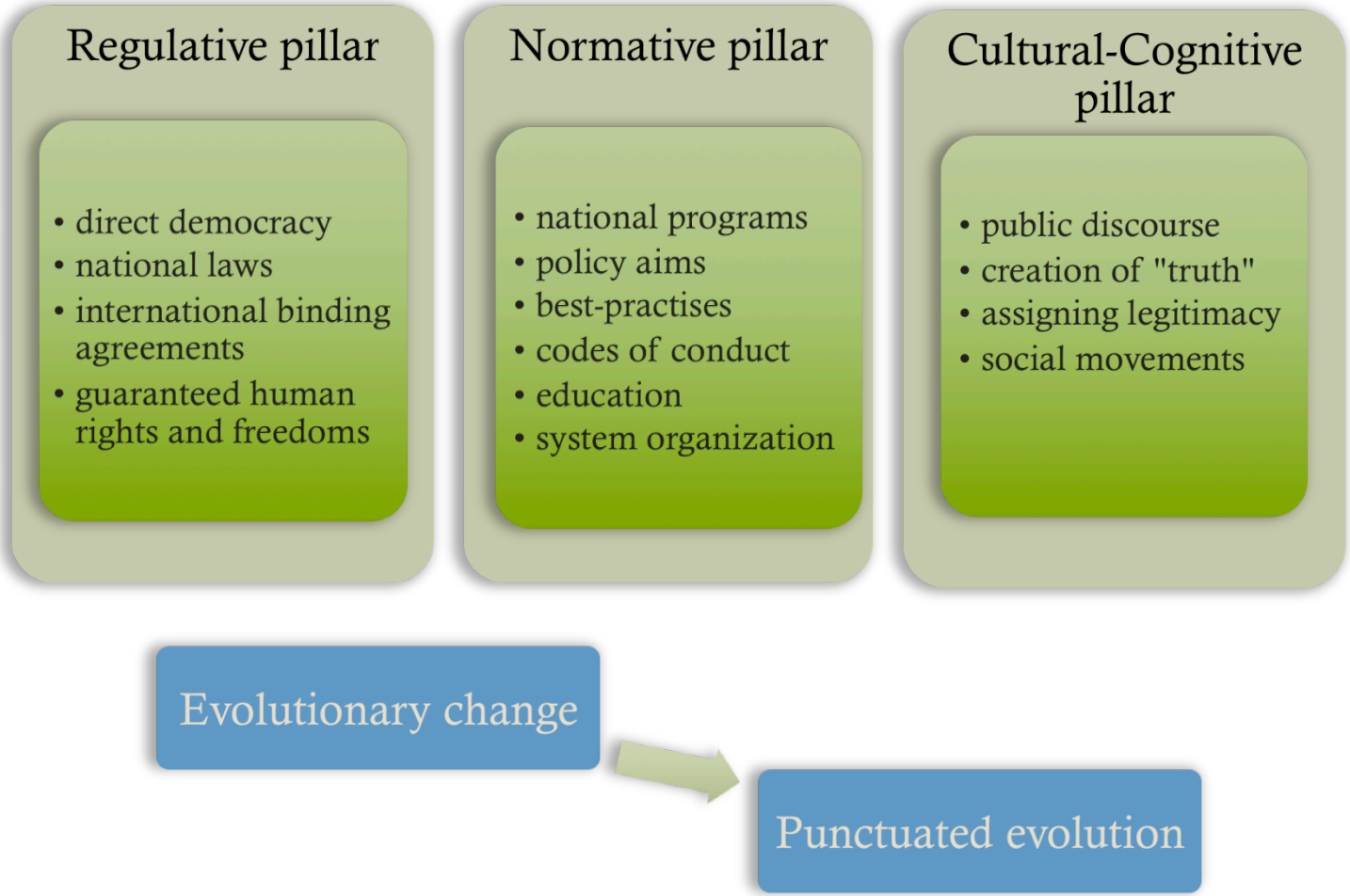
Institutional Change Analysis

Present situation

Radical technological change

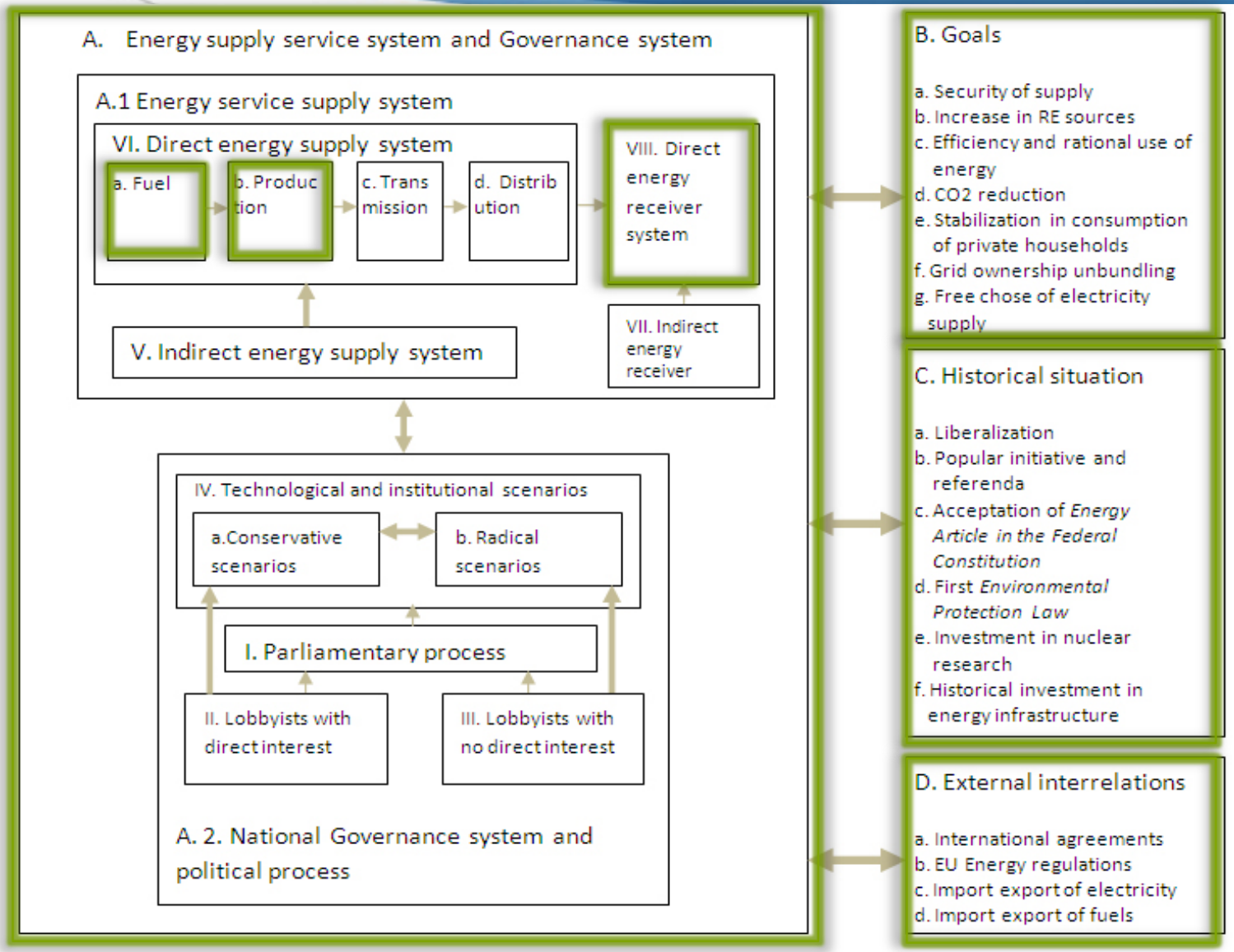
Future situation

Institutional Setting



Stakeholder Analysis

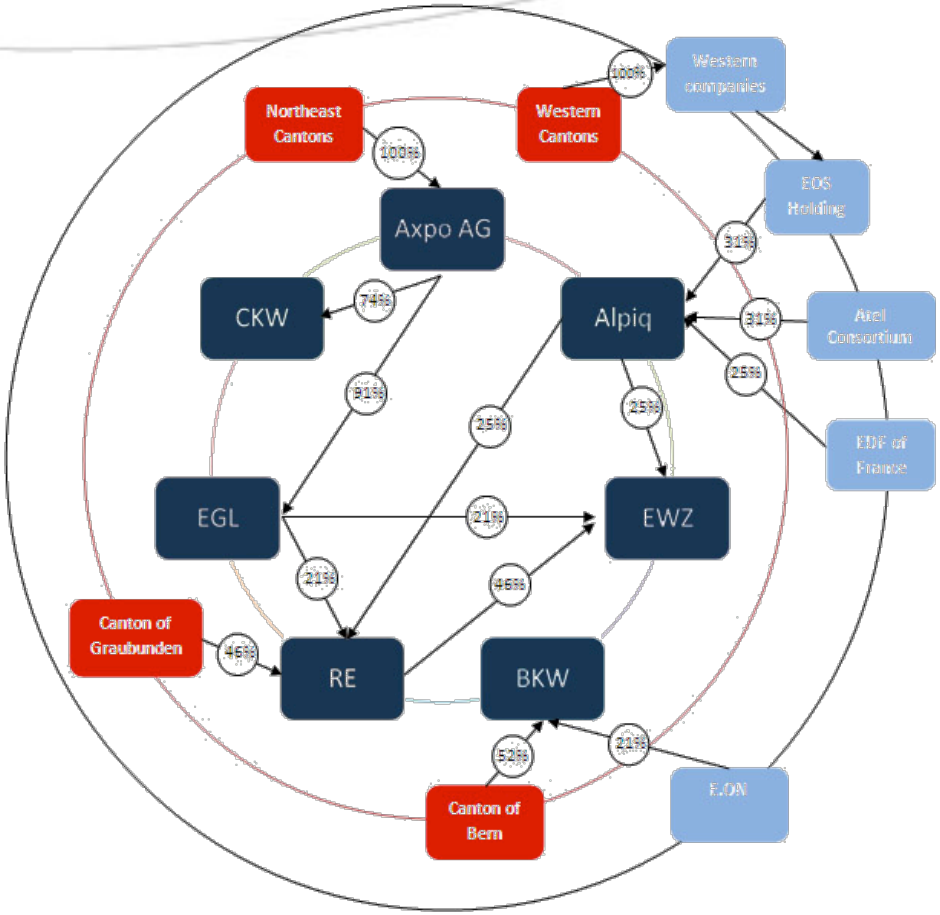
Macro Structure



Stakeholder Analysis

Micro Structure

- System Dynamics:
  - High degree of vertical integration
  - Complex ownership
  - Influence on political decision making process
  - RE companies have marginal role & are often subsidiaries of large providers



Inner circle: Shareholders of SwissGrid
Second circle: Public Shareholders
Third circle: Private Shareholders

Stakeholder Analysis

Interviews

Knowledge owners

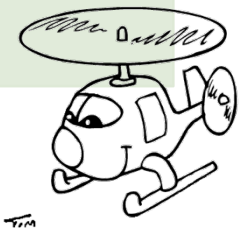
- Government
- Media
- Industry
- Scientific
- Academic
- NGO

Technique

- Helicopter interviews
- Questionnaire: open-ended, unbiased

Opinion camps

- Pro-nuclear
- Neutral
- Pro-renewable



Stakeholder Analysis

Interview Results

Common goals

- Energy security
- Climate change
- Affordability

Varied positions

- Priorities
- Solutions
- Concerns

Expressed issues

- Electricity gap
- Import dependency
- Liberalization
- Institutional barriers
- Political bias

Stakeholder Analysis

Interview Results

Motivation

- Grid stability
- Control
- Profit margins
- Financial support

Tools

- Lobbying
- Advertising

Support

- Institutional
  - nuclear
  - hydro
  - fossil fuel
- Public
  - hydro
  - solar
  - biomass

Stakeholder Analysis

Interview Results

System elements

- Increased RE
- Energy efficiency standards
- Smart grid
- Public transport
- Increase EVs

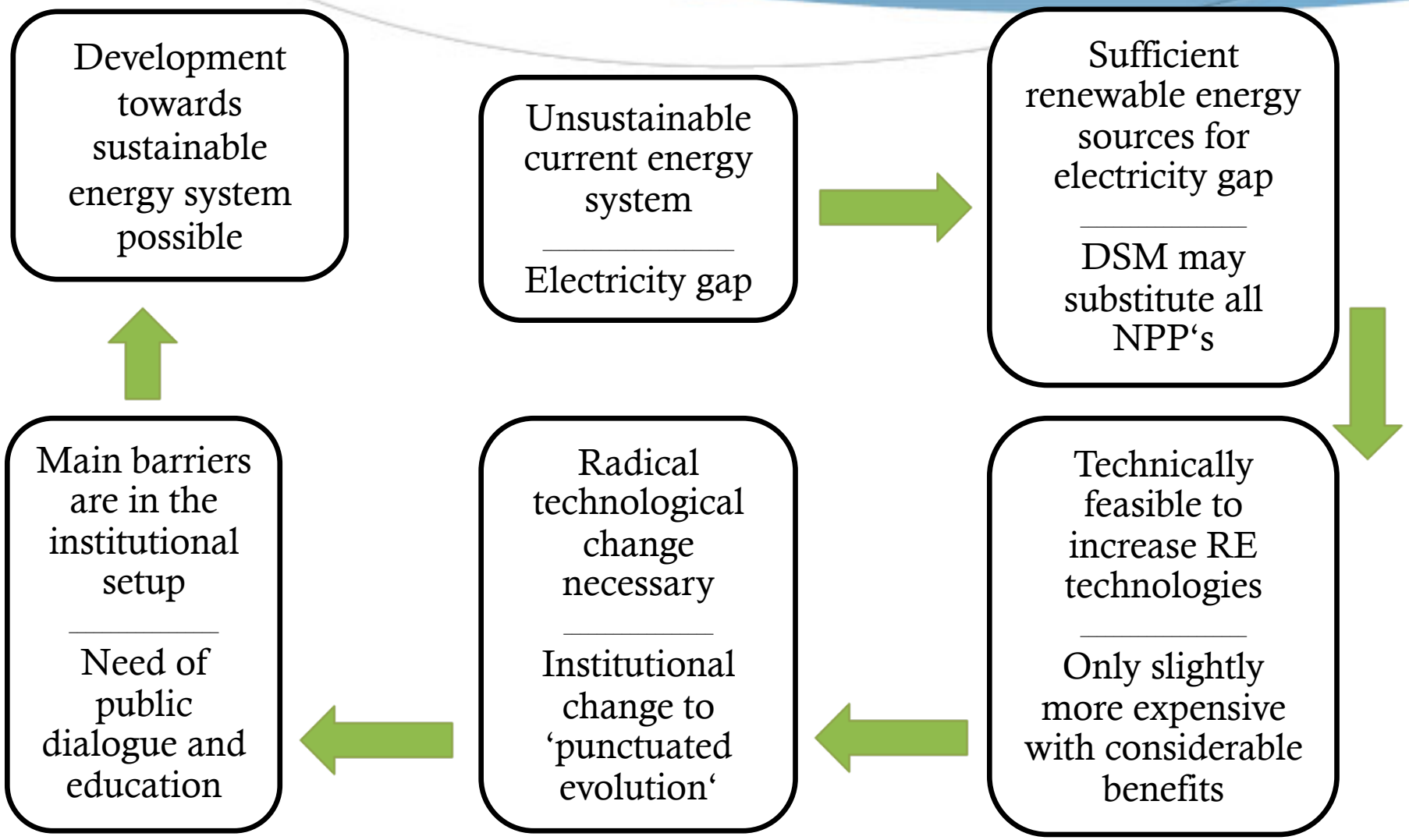
Goals

- Overcome influence
- Knowledge base creation
- Integration of EU energy policies

Policy tools

- Aggressive & accountable action plans
- Efficiency programs
- Emission taxes
- Remove legacy technology subsidies
- Increase RE incentives

Conclusions



Perspectives

- First hand local data could increase precision of modelling
  - Production and demand
  - Costs
  - Domestic value creation
  - Externalities
- Inclusion of external markets in the analysis
- Barriers to sustainable development have to be investigated further
- Specific steps towards institutional change have to be determined
- Research results should be translated into political action

Thank You For Your Attention!