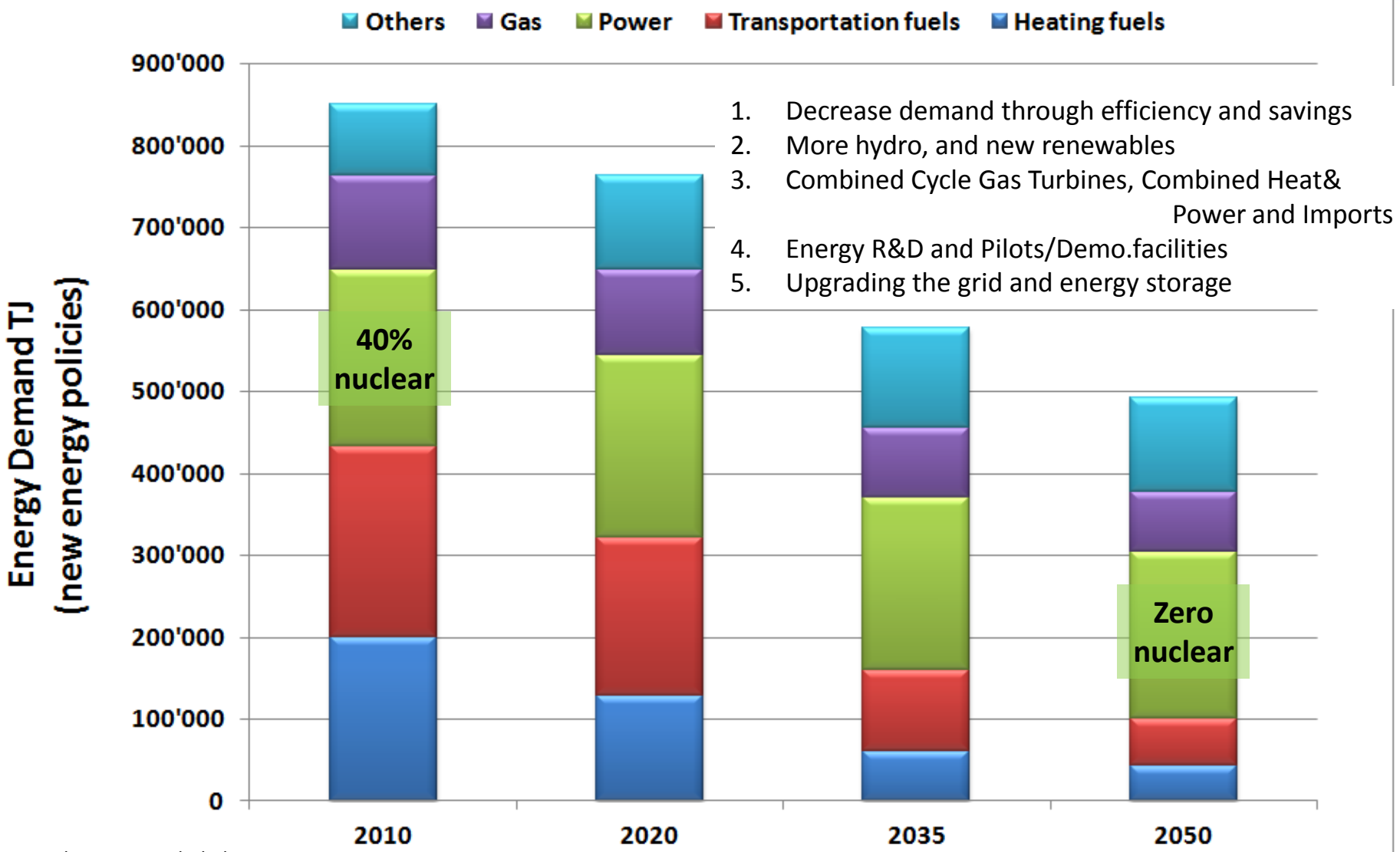
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Office fédéral de l'énergie OFEN
Ufficio federale dell'energia UFE
Swiss Federal Office of Energy SFOE

The Role of (deep) Geothermal Energy in Switzerland's Energy Strategy 2050

Gunter Siddiqi, Swiss Federal Office of Energy
Annual Conference 2014 Challenges and prospects for Hydro-Power and Deep Geothermal Electricity Production

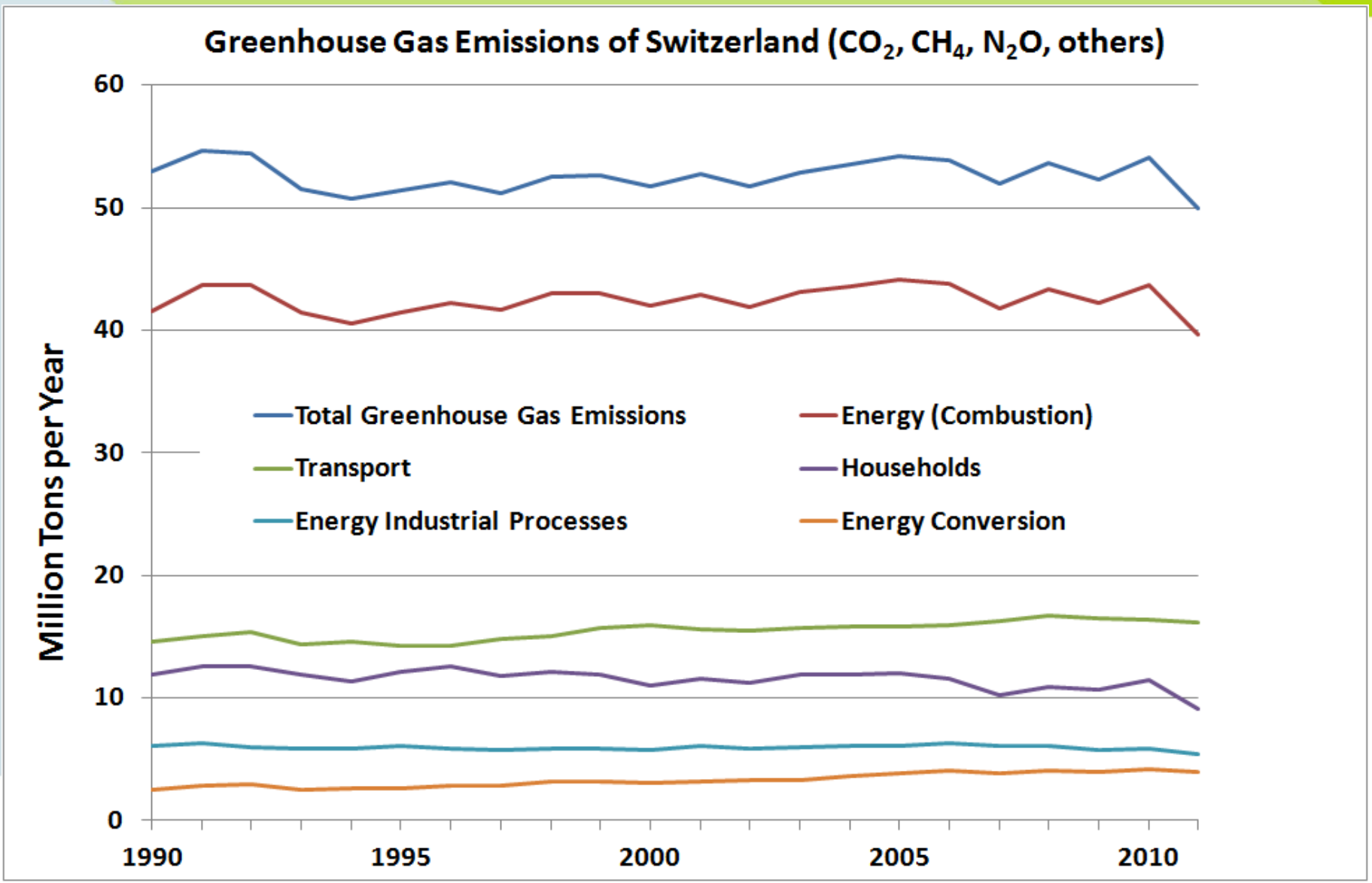
After Fukushima phased exit from nuclear energy: scenario for the definition of policy measures



Note: kerosene excluded

Source: Prognos, 2011 and Swiss Federal Office of Energy

Another major driver – Switzerland's Climate Policy

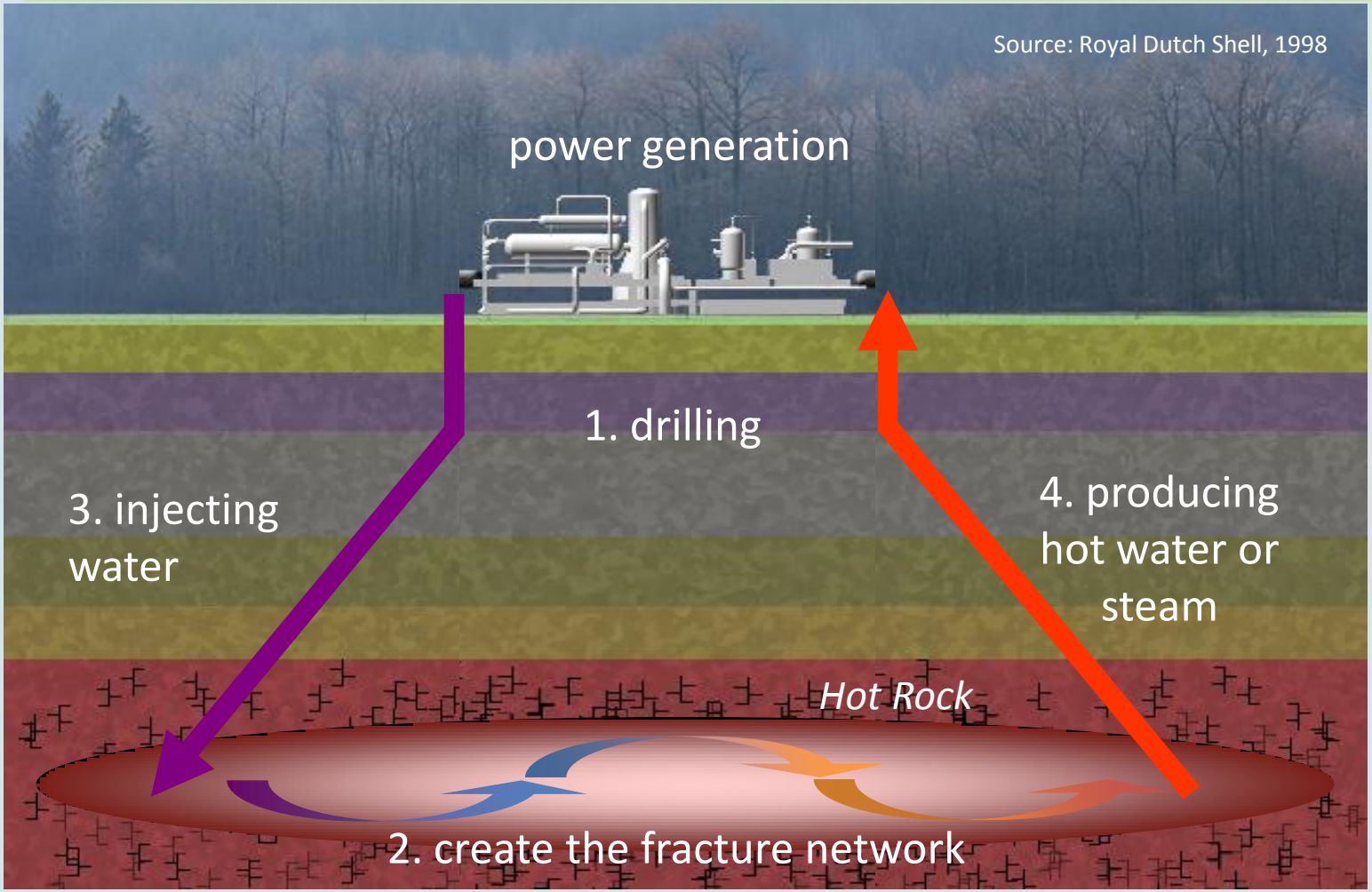


Parallel to Switzerland‘s Energy Strategy 2050: In parliament private member initiatives regarding geothermal

- Mo. 11.3562
  SR Gutzwiller: Deep Geothermal Energy. Masterplan.
- Mo. 11.3563*
  SR Gutzwiller: Deep Geothermal Energy. Exploring Switzerland
- Mo. 11.4027*
  NR Riklin: Action Plan Geothermal Energy

➔ *Swiss Federal Office of Energy has developed a conceptual plan and lis ooking for options to finance the exploration program

Enhanced/Engineered Geothermal Systems (EGS)



If there is plenty of natural hot water, then the system is hydrothermal

Which barriers can be overcome with the aid of government?

Governing ideas:

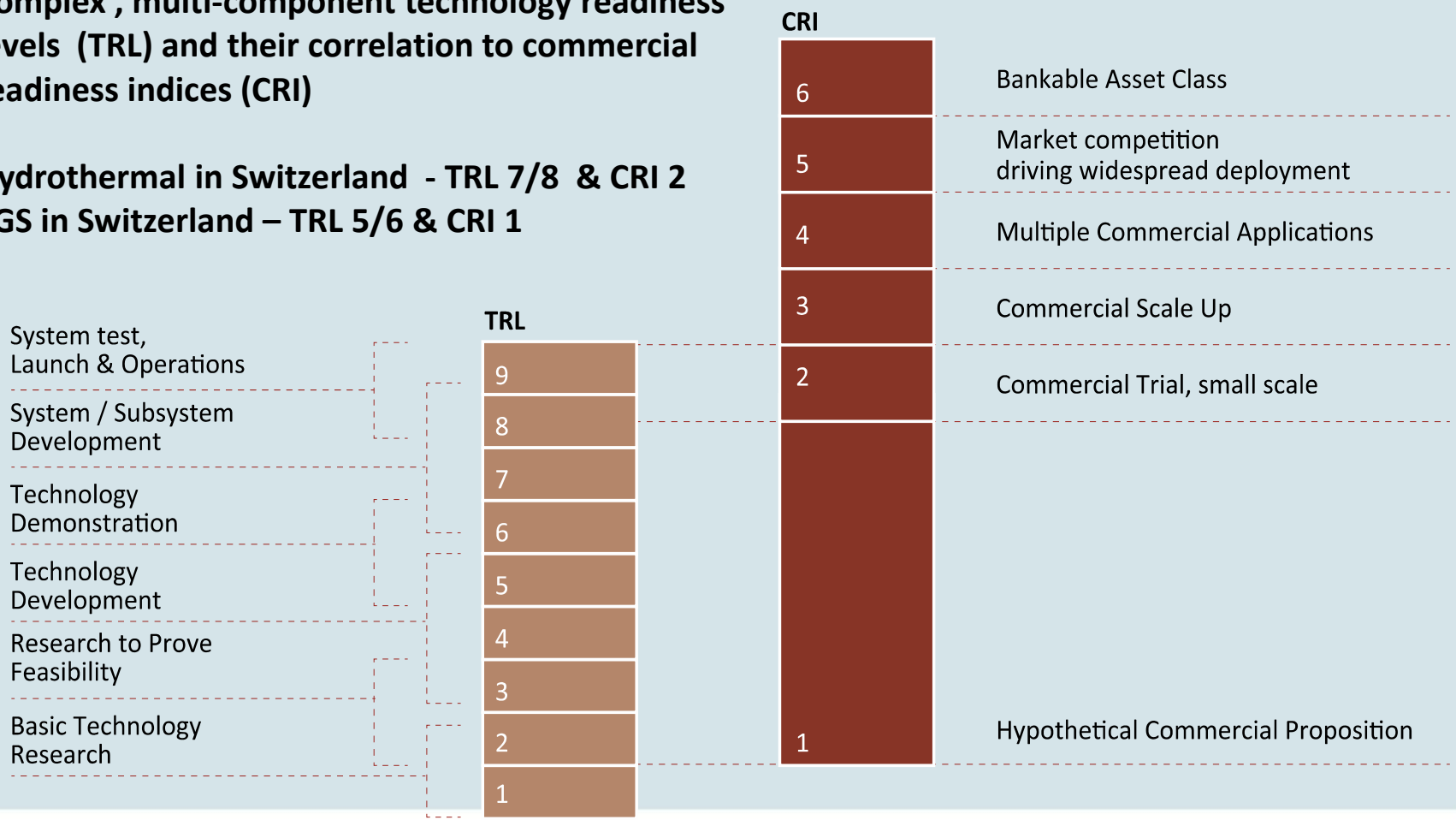
- Principal barriers for Switzerland
  - Exploration/Probability of Success
  - Accessing and developing the reservoir (incl. EGS)
  - Capabilities of participants in the (deep) geothermal industry sector
  - Robust legal framework
- Types of risk that can be carried or mitigated by the public
  - Technical: partially suitable (funded R&D, exploration)
  - Economical: partially suitable (feed-in tariffs, guarantee schemes)
  - Commercial: not suitable
  - Organizational: somewhat suitable (particularly building capabilities)
  - Political or societal: suitable (rules and regulations)
- In Switzerland: the federal government sets framework, industry executes
- Accounting for costs and affordability

See also “Risk Quantification and Risk Management in Renewable Energy Projects “
(Report commissioned by the IEA – Renewable Energy Technology Development)

Delivering technology readiness to enable commercial readiness

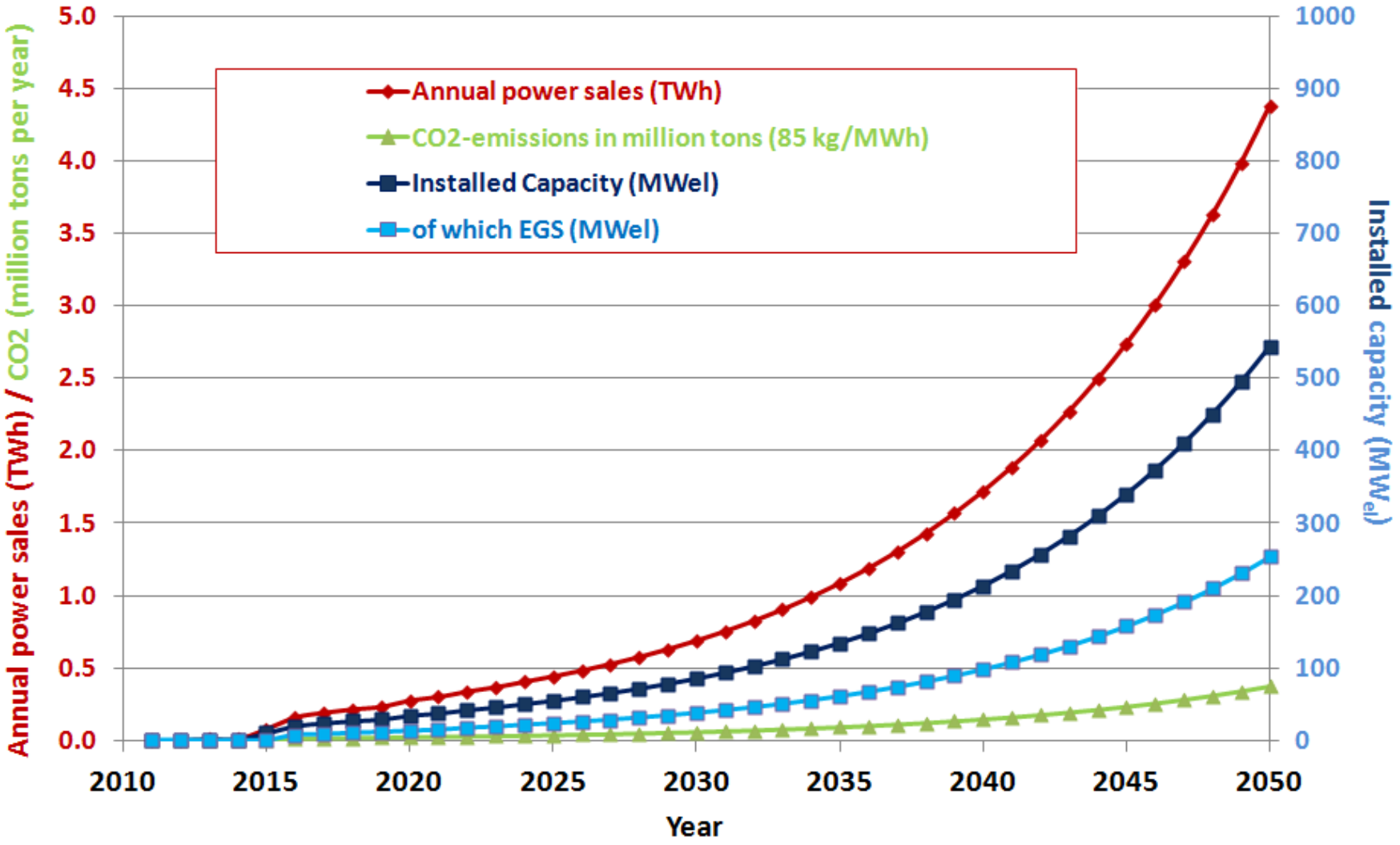
Complex , multi-component technology readiness levels (TRL) and their correlation to commercial readiness indices (CRI)

Hydrothermal in Switzerland - TRL 7/8 & CRI 2
EGS in Switzerland – TRL 5/6 & CRI 1



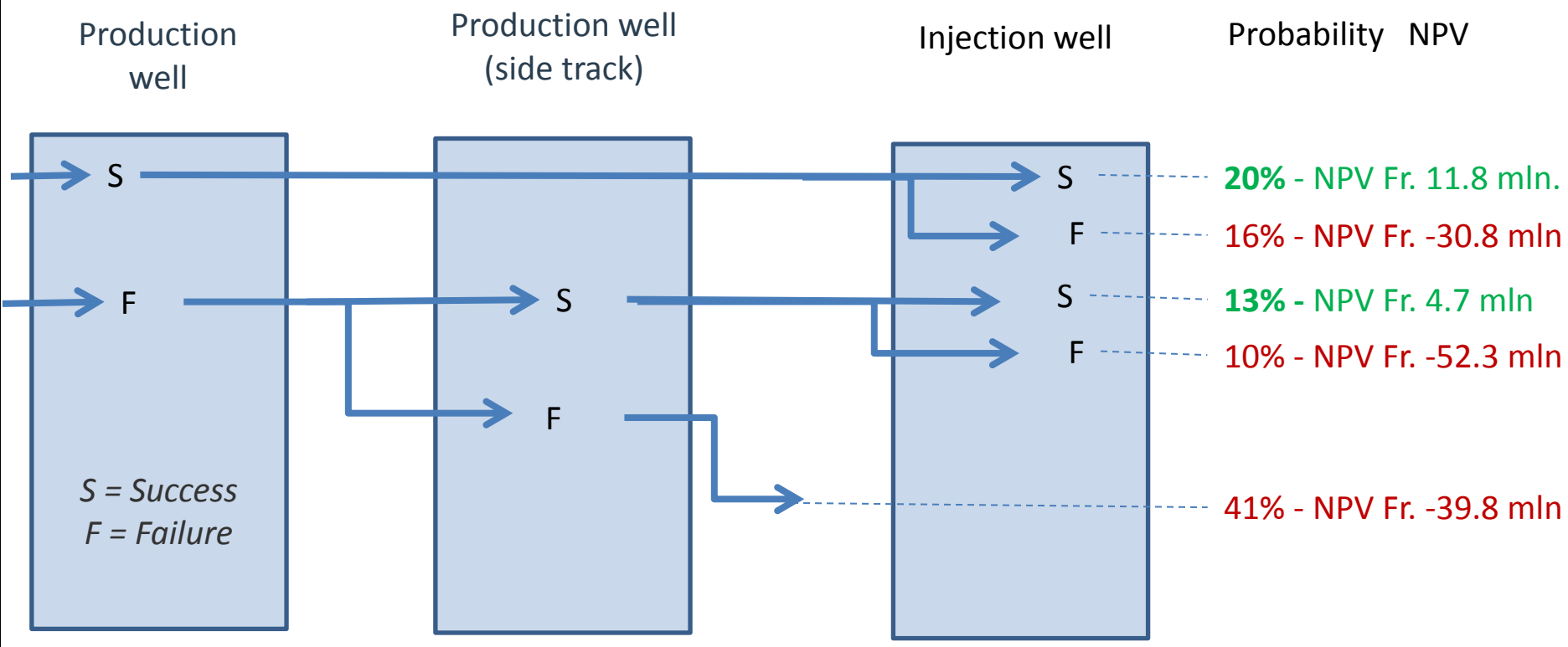
Source: Australian Government, Australian Renewable Energy Agency (2014) LOOKING FORWARD: BARRIERS, RISKS AND REWARDS OF THE AUSTRALIAN GEOTHERMAL SECTOR TO 2020 AND 2030

Detailed scenario to develop technology policies: scenario for geothermal power



Source: Swiss Federal Office of Energy

Why Enhanced Geothermal Systems & exploration are important



P_{temp} = 0.9
$P_{struct.}$ = 0.8
P_{trans} = 0.5

Probability of Success = ΠP = **S =** 0.9*0.8*0.5 = **36%**

F = 1-S **= 64%**

P_{temp} = 0.9
$P_{struct.}$ = 0.8
P_{trans} = 0.5

Probability of Success = ΠP = **S =** 0.9*0.8*0.5 = **36%**

F = 1-S **= 64%**

P_{temp} = 1
P_{struct} = 0.8
$P_{inj.}$ = 0.7

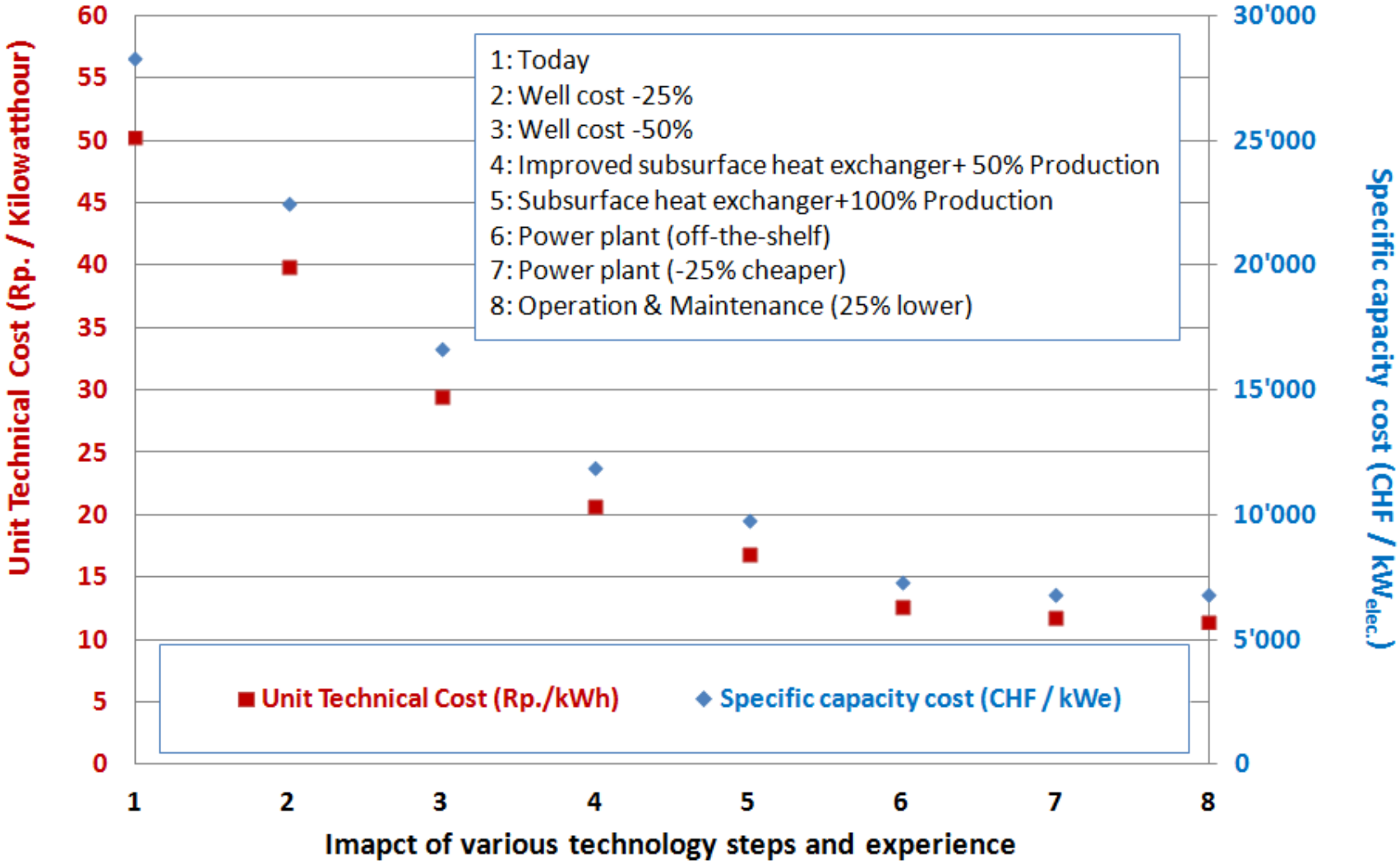
Probability of Success = ΠP = **S =** 1*0.8*0.7 = **56%**

F = 1-S **= 44%**

Source: Swiss Federal Office of Energy

Identifying cost drivers & potential for cost reductions

Two wells to AHD 5000 m (CHF 48 mln); 17 $MW_{th.}$, Power 3 MW_{el} (ORC: CHF 13 mln), Cost of capital 3.5%



Quelle: Bundesamt für Energie

Support for geothermal in Switzerland

Estimated Monetary Value of a Project (EMV)
=
Probability of Success (POS) * $NPV_{success}$
+
Probability of Failure * $NPV_{failure}$

Installed Capacity (P_{el})	Feed-in tariff (Rp./kWh)
≤ 5 MW	40.0
≤ 10 MW	36.0
≤ 20 MW	28.0
> 20 MW	22.7

EMV

$= POS*NPV_{success}$

$+ (1-POS)*NPV_{failure}$

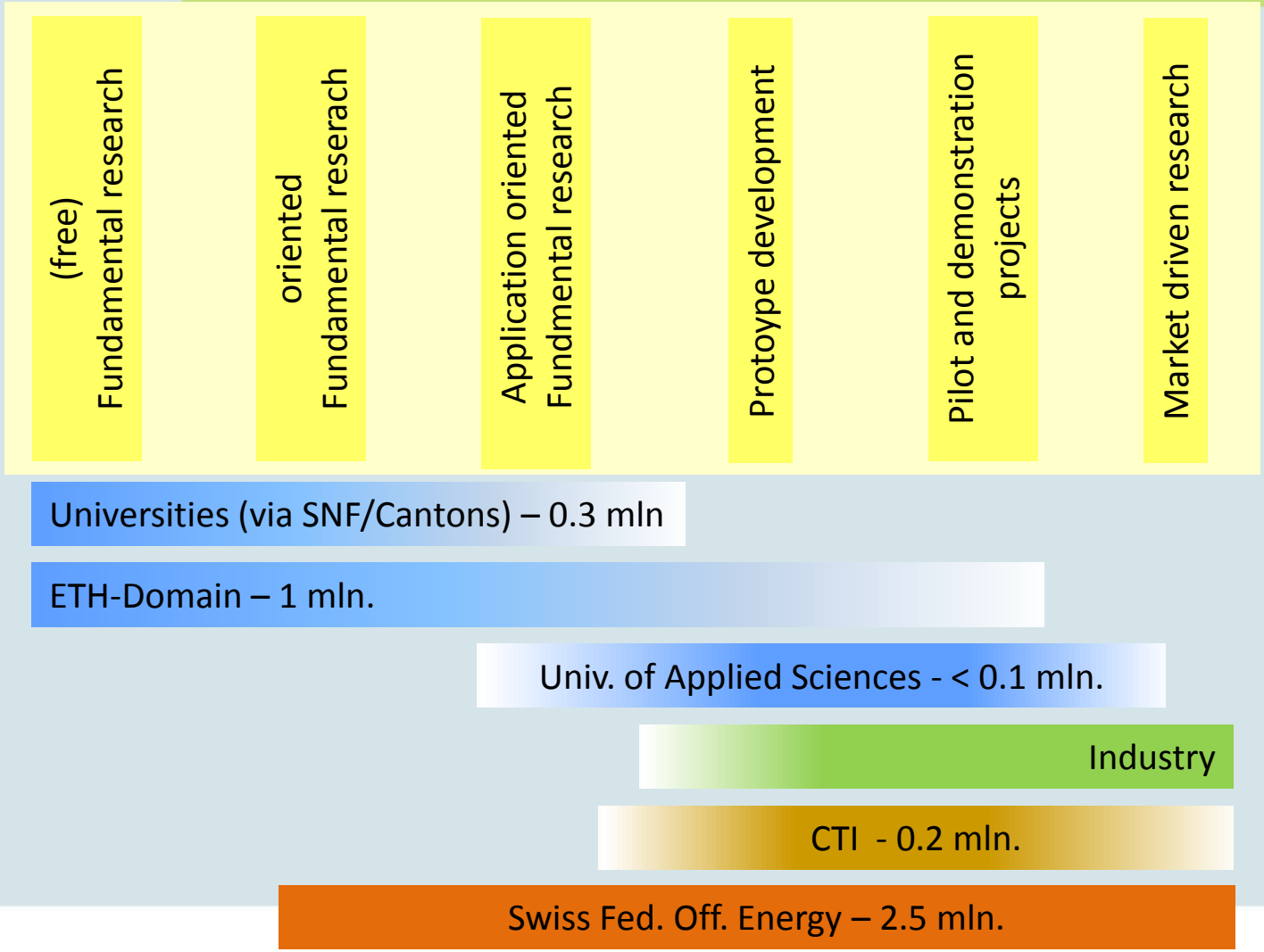
Federal risk guarantee: CHF 150 million (up to 50% of sunk subsurface project development cost may be reimbursed)

Federally sponsored R&D projects
and funds for pilot and demonstration projects
- Swiss Fed. Office of Energy (dominant)
- Swiss Nat. Science Foundation
- ETH Domain
- CTI Swiss Innovation Promotion Agency

Energy Act currently in revision: more in store after 2017

Source: Swiss Federal Office of Energy

Developing geothermal energy along its value chain – Funding for projects (mln CHF in 2012 – sources of federal funds)



Annual expenditures (expected) 2013/14 – 2016*

CHF 7 – 8 mln per year (excl. major pilot projects)

* See also Dispatches on Research and Innovation 2013-16 & Coord. Energy Research

Source: BFE

Certainly not alone: essential for success is close cooperation and leveraging scarce resources

International Partnership for Geothermal Technology

Long term cooperation with
Australia, Iceland, New Zealand and USA
on Enhanced Geothermal Systems

IEA Geothermal Implementing Agreement — IEA GEOTHERMAL

Deeply rooted in the
International Energy Agency's
Geothermal Implementing Agreement

Geothermal ERA-NET

Linking 9 European national geothermal RD&D programs

GeoMol

Assessing subsurface potentials of the Alpine Foreland Basins for sustainable planning and use of natural resources

and working with the European Union
- ERANET (European Research Area Networks) Cofund Actions – program owners coordinate
- European Energy Research Alliance EERA – researchers cooperate
- Research and Development Framework Programs – National program owners and European Commission finance

Another piece in the puzzle: storing CO_2 in the subsurface

Looking into the future (Weidmann, PSI, PhD 2013)

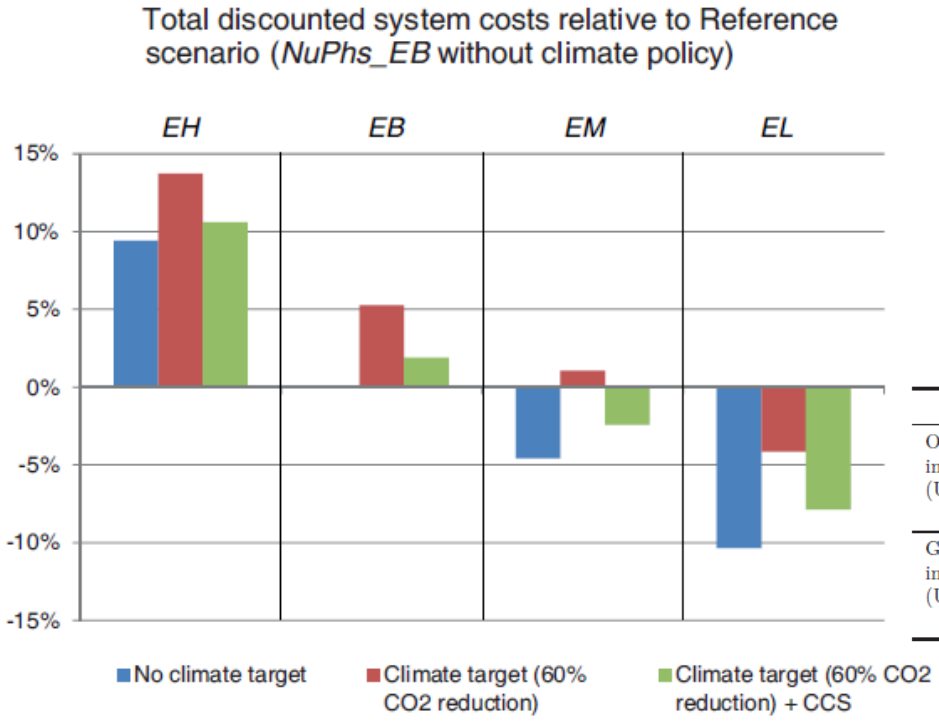


Figure 5.12: Comparison of additional total discounted system costs relative to the nuclear phase-out scenario with business as usual fossil fuel prices and no climate target (*NuPhs_EB* scenario) for different fossil fuel price levels (high, business as usual, medium, and low) in scenarios without climate target, with 60% CO_2 emissions reduction target, and with 60% CO_2 emissions reduction target with CCS.

4 fossil fuels price Sensitivities:
EH – high
EB – base case
EM – medium prices
EL – low prices

		2010	2020	2025	2030	2035	2040	2045	2050
Oil (IEA crude oil import price) (USD_{2010}/bbl)	2DS	78	97	98	98	98	92	89	87
	4DS	78	109	114	117	120	119	119	118
	6DS	78	118	127	134	140	143	146	149
	6DS+50%	78	133	151	168	184	197	210	224
Gas (Europe import price) (USD_{2010}/Mbtu)	2DS	7	10	10	10	9	9	9	8
	4DS	7	10	11	12	12	12	12	12
	6DS	7	11	12	13	13	13	14	14
	6DS+50%	7	12	14	16	17	18	20	21

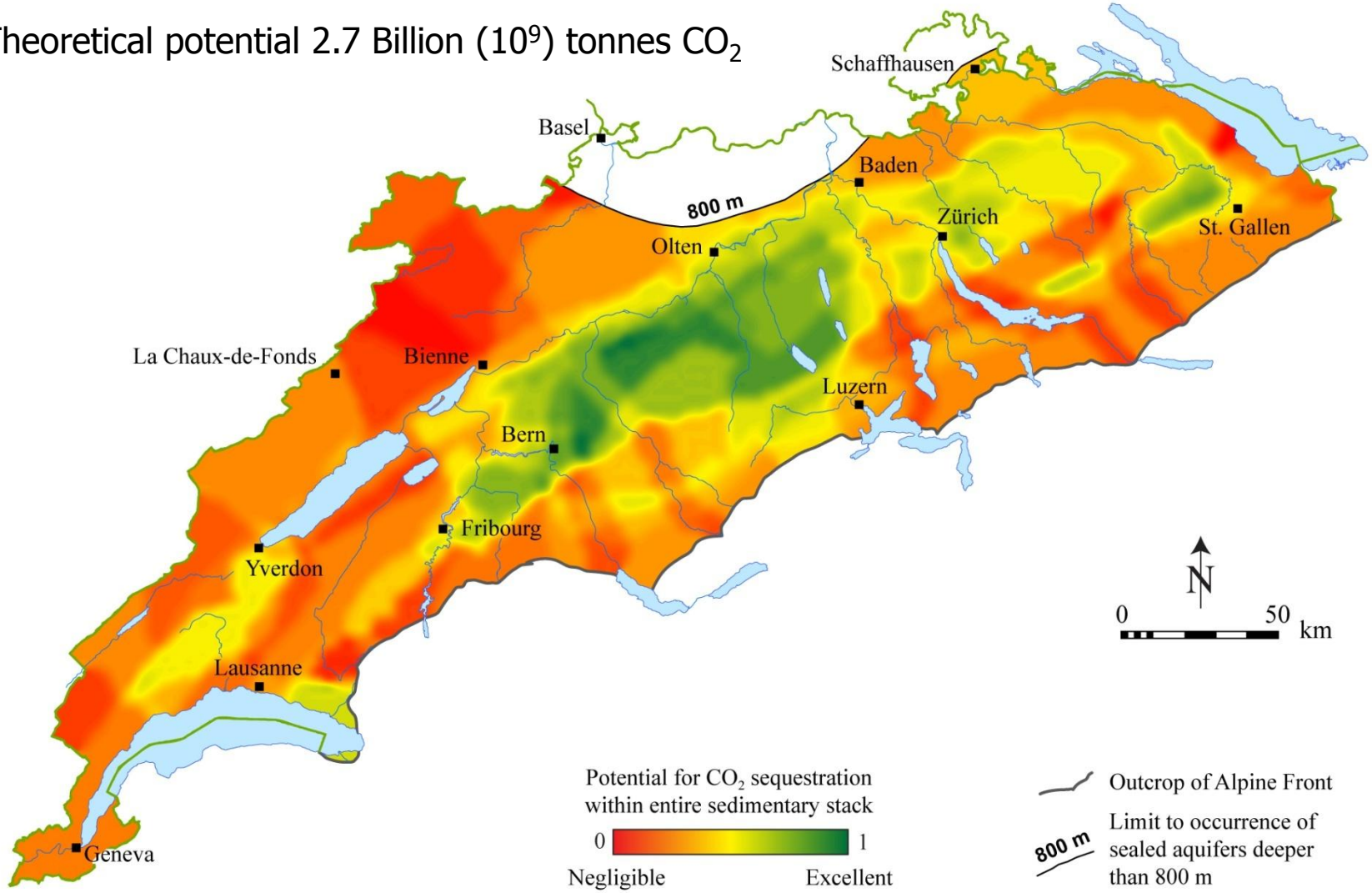
Fossil fuels with CCS may provide an attractive option if new renewables cannot deliver

Unless certain requirements are met, CCS is not an option for Switzerland

- Are Switzerland's large stationary emission point sources available for CCS?
- Does industry have an interest in CCS?
- Can open questions (risks, liability, monitoring) be resolved?
- Will it be acceptable to the public?
- But, also the fundamental question: ***Does storage potential meet demand?***

Overall CO_2 storage potential of Switzerland appears to be worth investigating further – critical step is injectivity pilot

Theoretical potential 2.7 Billion (10^9) tonnes CO_2



Source: Diamond et al., SFOE Study, 2010

Here too, a link to Europe is particularly useful to leverage capacities, capabilities and funding

- Building R&D capacities and capabilities
  - In Switzerland: Swiss Competence Center for Energy Research SCCER
  - One of 8 is the SCCER Supply of Electricity which addresses CO_2 storage

- Building Research Infrastructure networks
  - Linking research infrastructures throughout Europe
  - ECCSEL – the European Carbon Dioxide Capture and Storage Laboratory Infrastructure across 10 countries: Norway; France; The Netherlands; Germany; UK; Switzerland (ETHZ); Spain; Italy; Greece and Poland

- Creating opportunities to execute CO_2-injectivity pilot tests:
  - European Research Area Networks (ERANET) Cofund Action CFA on CCS: pooling national resources with top-up from the European Commission (Norway, Germany, Italy, Switzerland, Romania, The Netherlands, UK, France and Greece)

Geothermal & other subsurface energy sources are not for the faint of heart!

Source: Gunter Siddiqi, SFOE

Deep geothermal energy in Switzerland – a mix of support measures

Technology development:

1. Build up of R&D capacity and capabilities

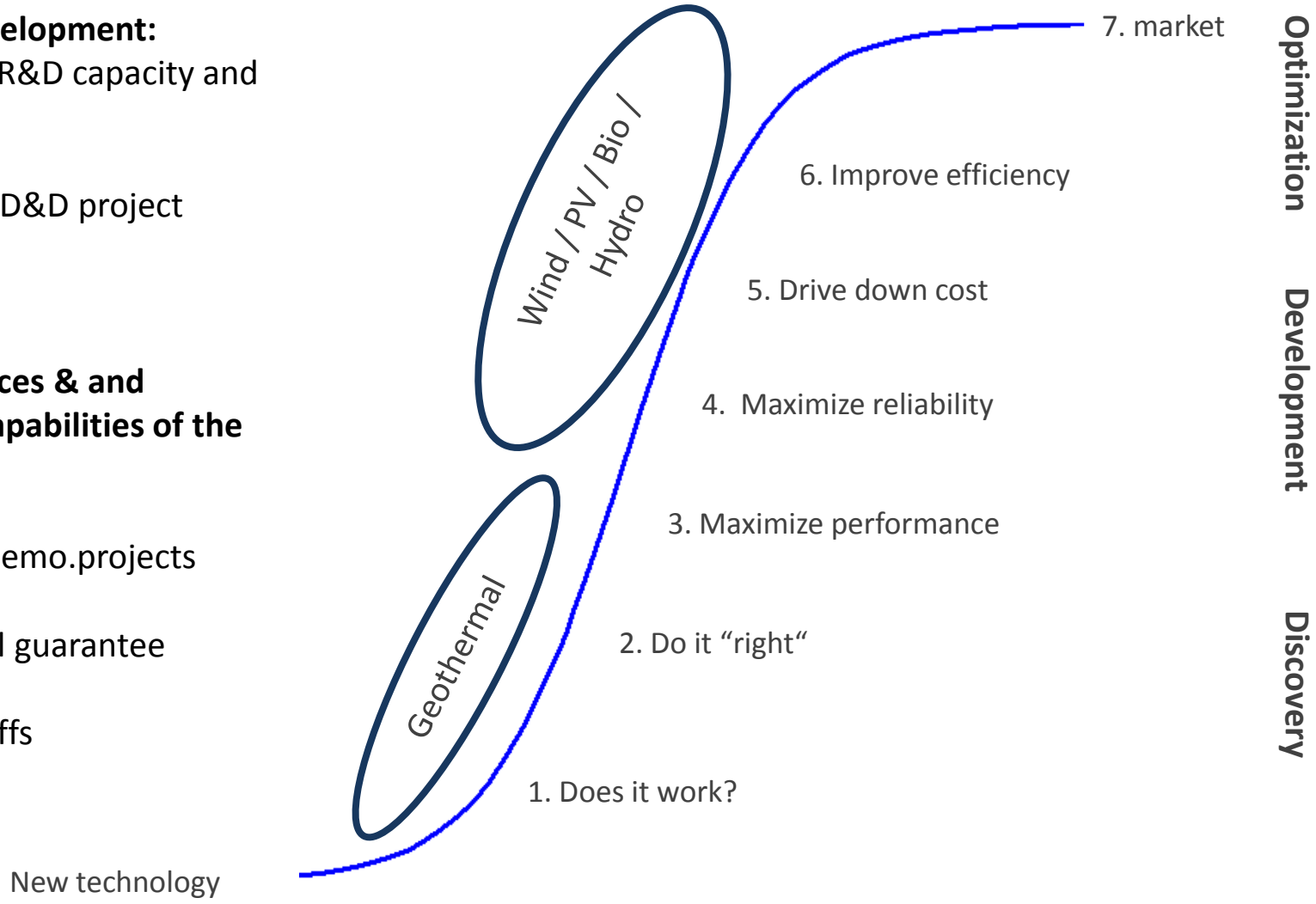
2. Increased RD&D project support

Develop resources & and technical capabilities of the industry:

3. Pilot- and Demo.projects

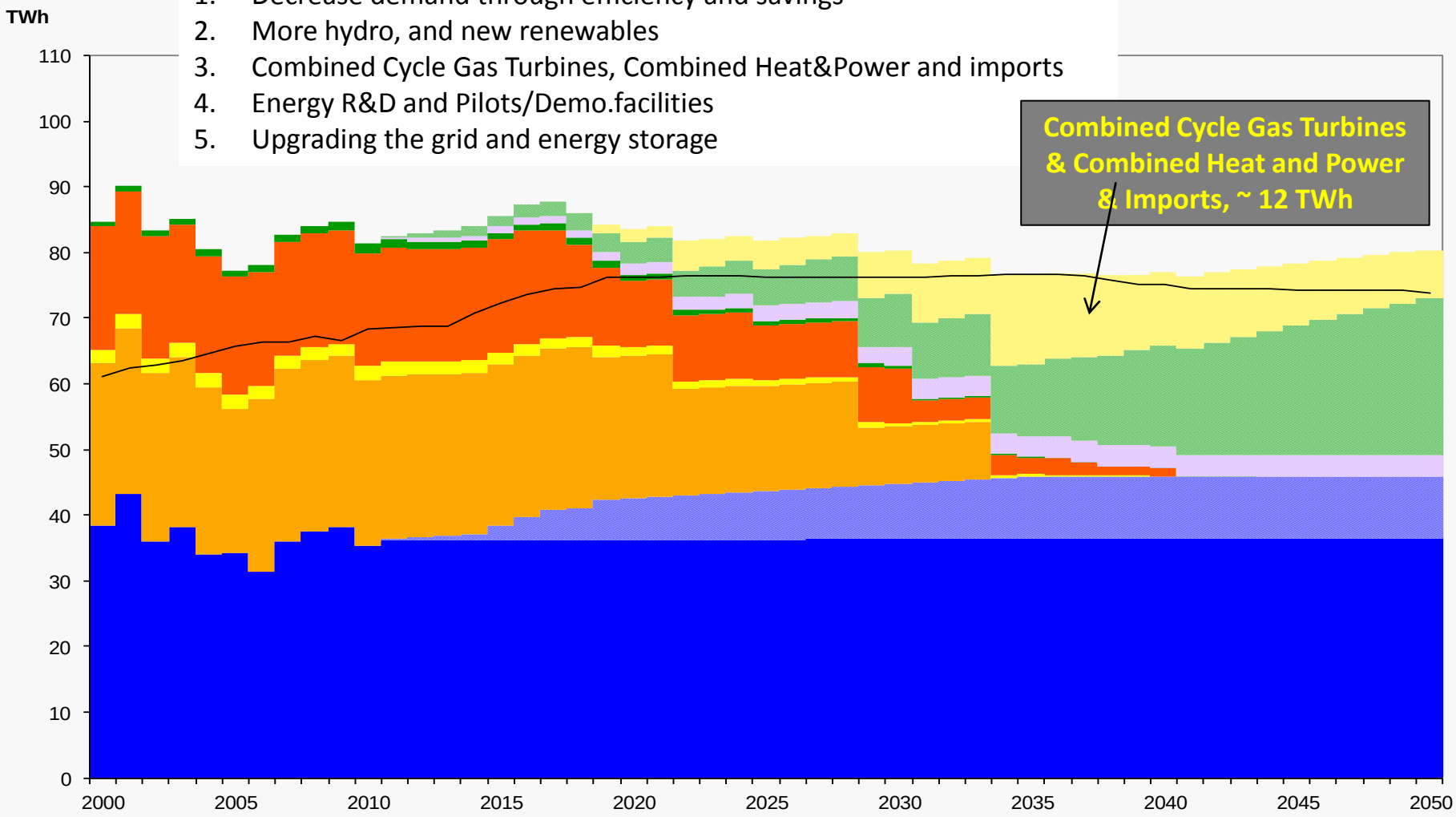
4. Geothermal guarantee

5. Feed-in tariffs



Energy Strategy 2050:
A scenario for power supply and demand

1. Decrease demand through efficiency and savings
2. More hydro, and new renewables
3. Combined Cycle Gas Turbines, Combined Heat&Power and imports
4. Energy R&D and Pilots/Demo.facilities
5. Upgrading the grid and energy storage



*) gekoppelt und ungekoppelt

Quelle: Prognos 2012

Energy Strategy 2050:
Power from Geothermal Energy – a Long Term Option!