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Photonics for Deep Geothermal Energy Harvesting

POTENTIAL of *Deep Geothermal Energy* in the Energy Debate

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Since **Deep Geothermal Energy** provides both
Heat and **Electricity,** in short it is called : **GEOENERGY**

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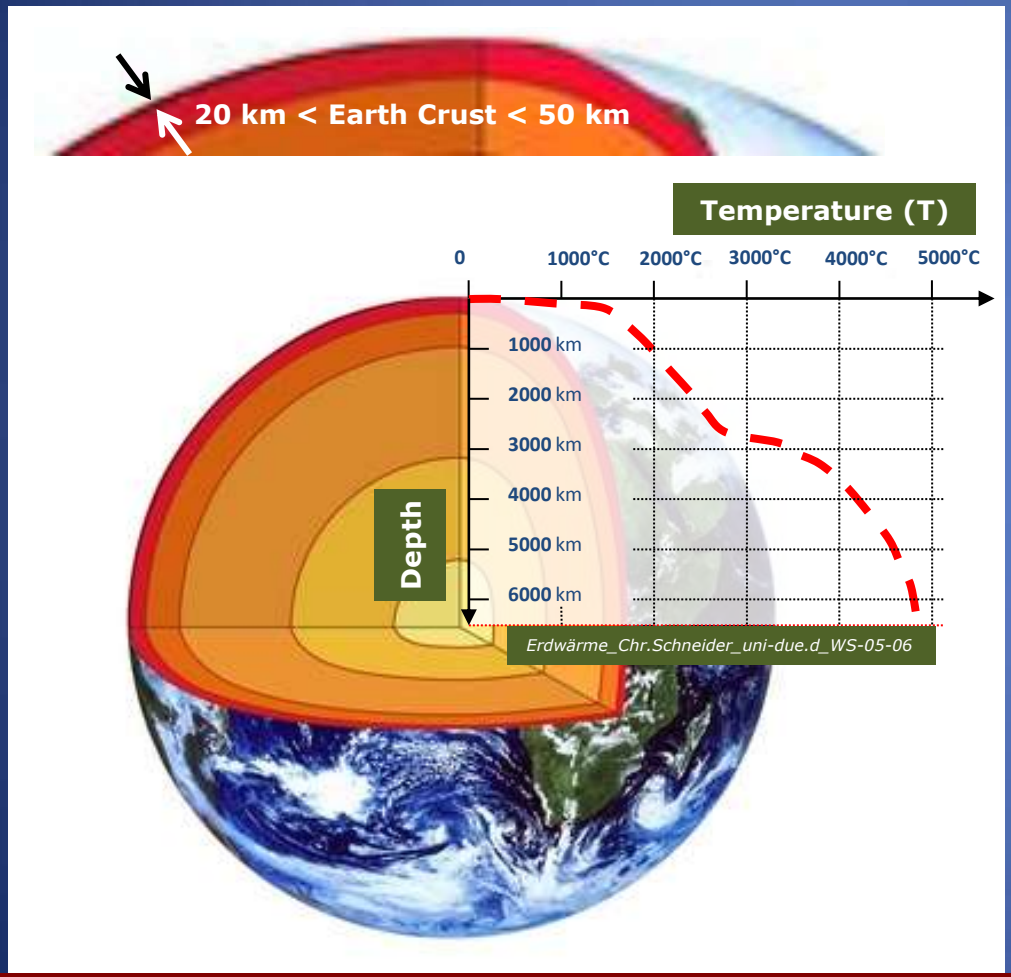
a) TEMPERATURE depending on DEPTH



- **Within** the **earth's crust :** the **temperature gradient** is **much higher** than further inside
- At the inner boundary of the earth's **crust :** **T > 1000 °C**
- In the earth's **center :** **T = 5000°C**

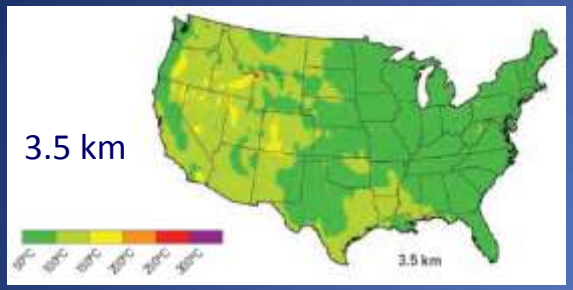
➔ **99%** of the earth's **volume :** **T > 1000°C**

➔ We are sitting on an **inex-haustible occurrence of heat,** due to
  - **radioactive decay**
  - **condensation heat** (the transition of liquid to solid state causes the dint in dotted line)

Next point of interest: **DISTRIBUTION** of **temperature** in a **plane** of a certain **depth**

b) DISTRIBUTION of temperature in a plane on a certain depth

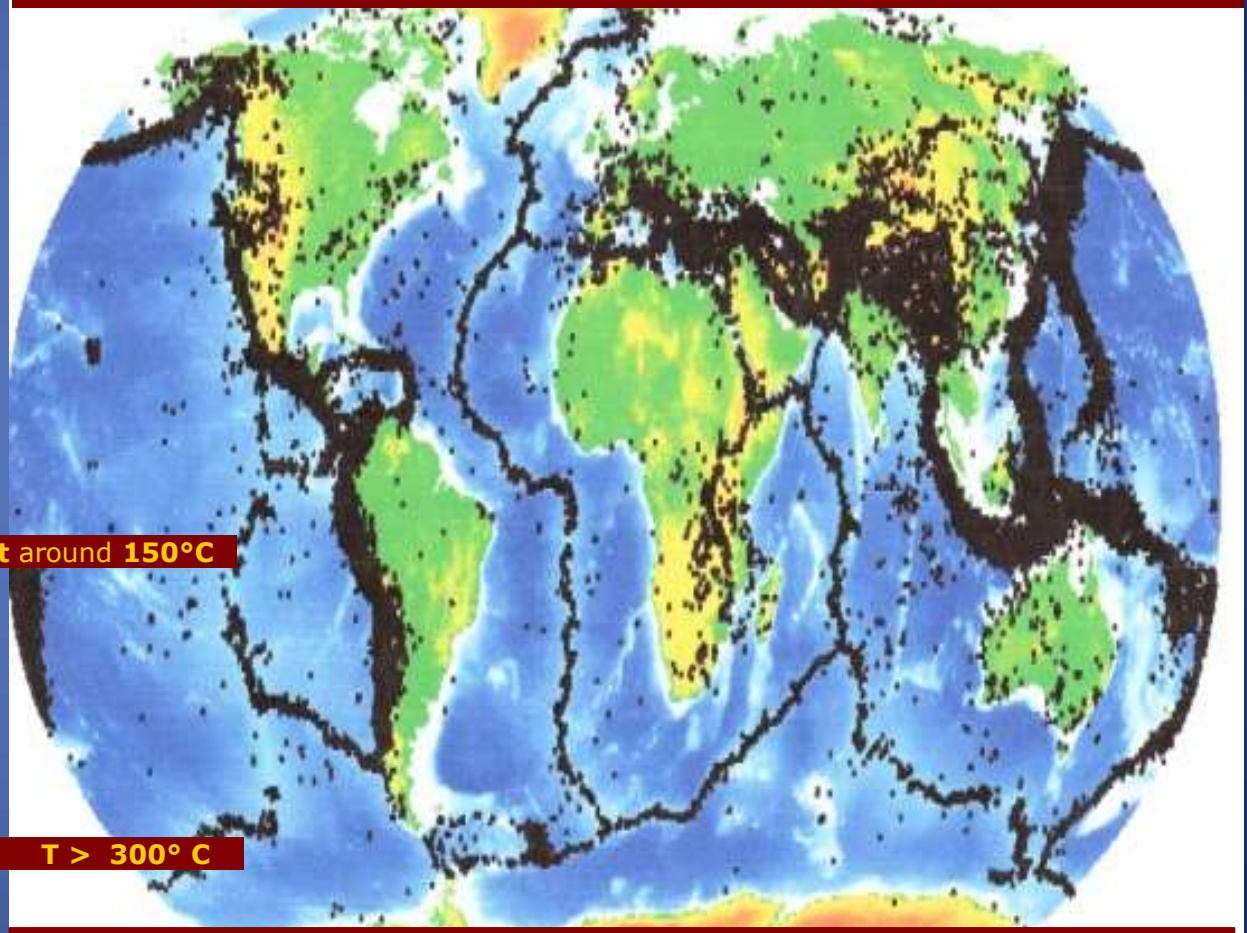
Universally valid the two statements: a) in **10 km** depth the temperature is **at least 150°C** , b) **US = representative** for globe



in **10 km** depth: in the **cooler east** around **150°C**

where is seismicity in **10 km** depth: **T > 300° C**

Earthquakes (M > 4) **1980 – 2002** *World Data Center for Seismology, Denver*

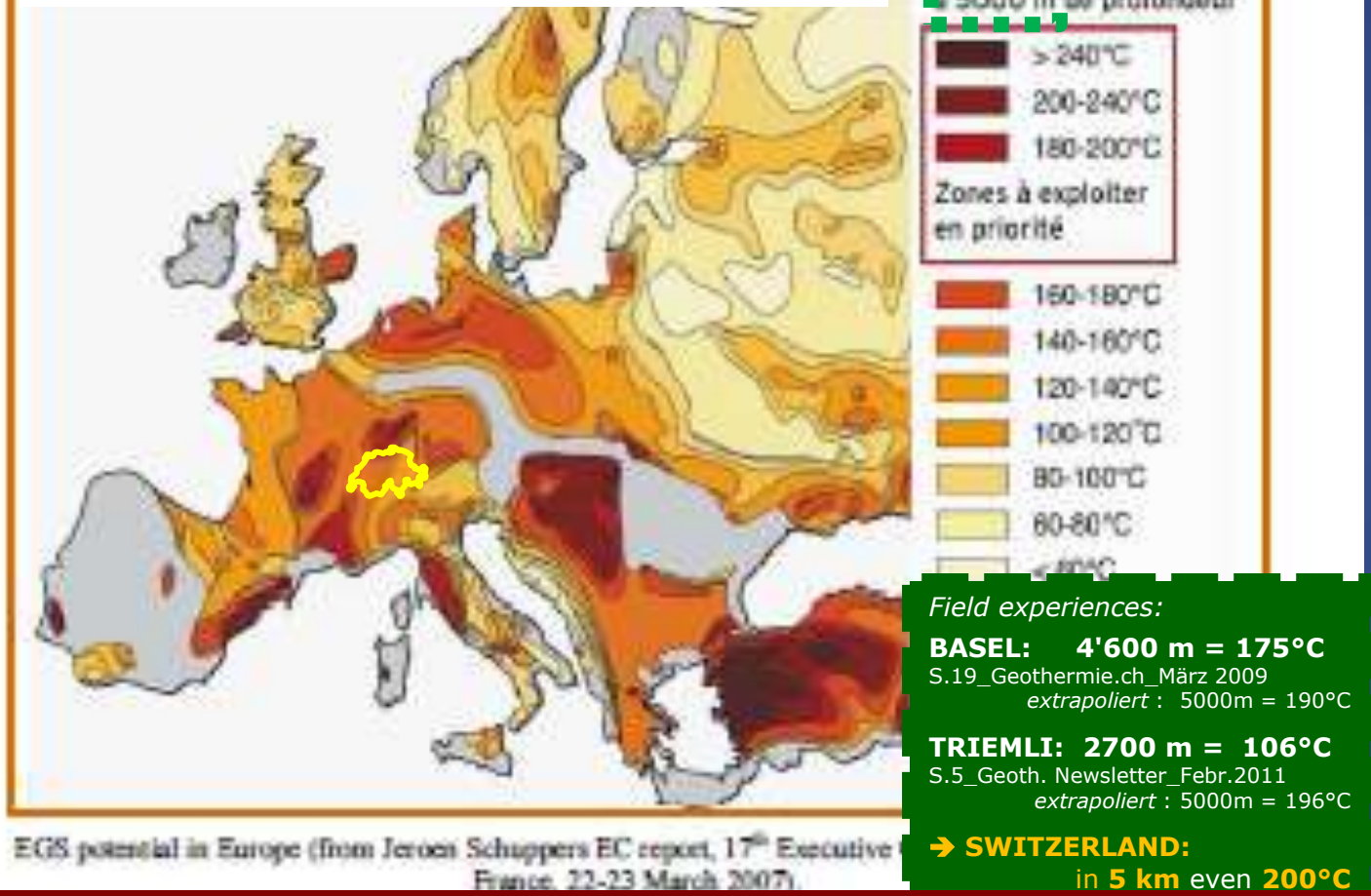


EUROPE is rather **comparable** with **West** than East of US
➔ **T** really about **300° C** in **10 km** in **Europe ?**

c) **DISTRIBUTION** of temperature in **5000m** depth in **EUROPE**

Yes, **Europe** is **comparable** to **California** with about **150°C** in **5 km**

p. 97_IEA (International Energy Agency),
Geothermal Energy Annual-Report (06-Jan.2008)



EGS potential in Europe (from Jeroen Schuppers EC report, 17th Executive France, 22-23 March 2007)

Field experiences:

BASEL: **4'600 m = 175°C**
S.19_Geothermie.ch_März 2009
extrapoliert : 5000m = 190°C

TRIEMLI: **2700 m = 106°C**
S.5_Geoth. Newsletter_Febr.2011
extrapoliert : 5000m = 196°C

➔ **SWITZERLAND:**
in **5 km** even **200°C**

Decisive question: What **ENERGY CONTENT** corresponds to such temperatures ?

d) ENERGY CONTENT at such temperatures

The **heat content** of a **cube** with

- a side length of **10 km,**
- a temperature of **240°C**

equalizes the **total yearly energy consumption** of the **WHOLE world**.

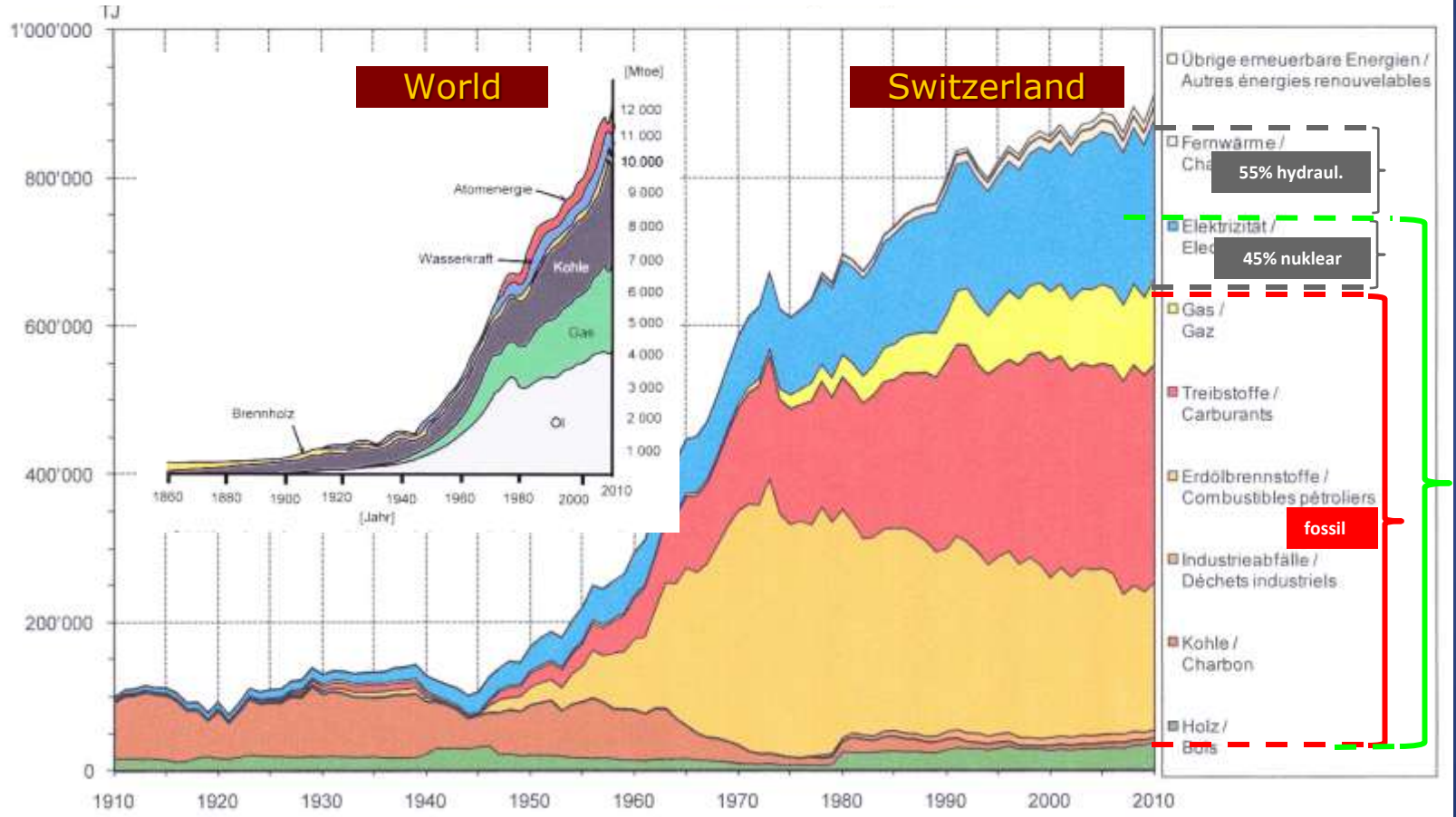
Such a cube represents a **negilgible tiny little bit of the earth's crust,** up to **50** km thick and **enveloping** the **ENTIRE** globe

Conclusion : The **PHYSICAL Potential of Deep Geothermal Energy is UNLIMITED**

II) POLITICAL Energy Debate

a) **Energy consumption** and the **„Energy Change"**

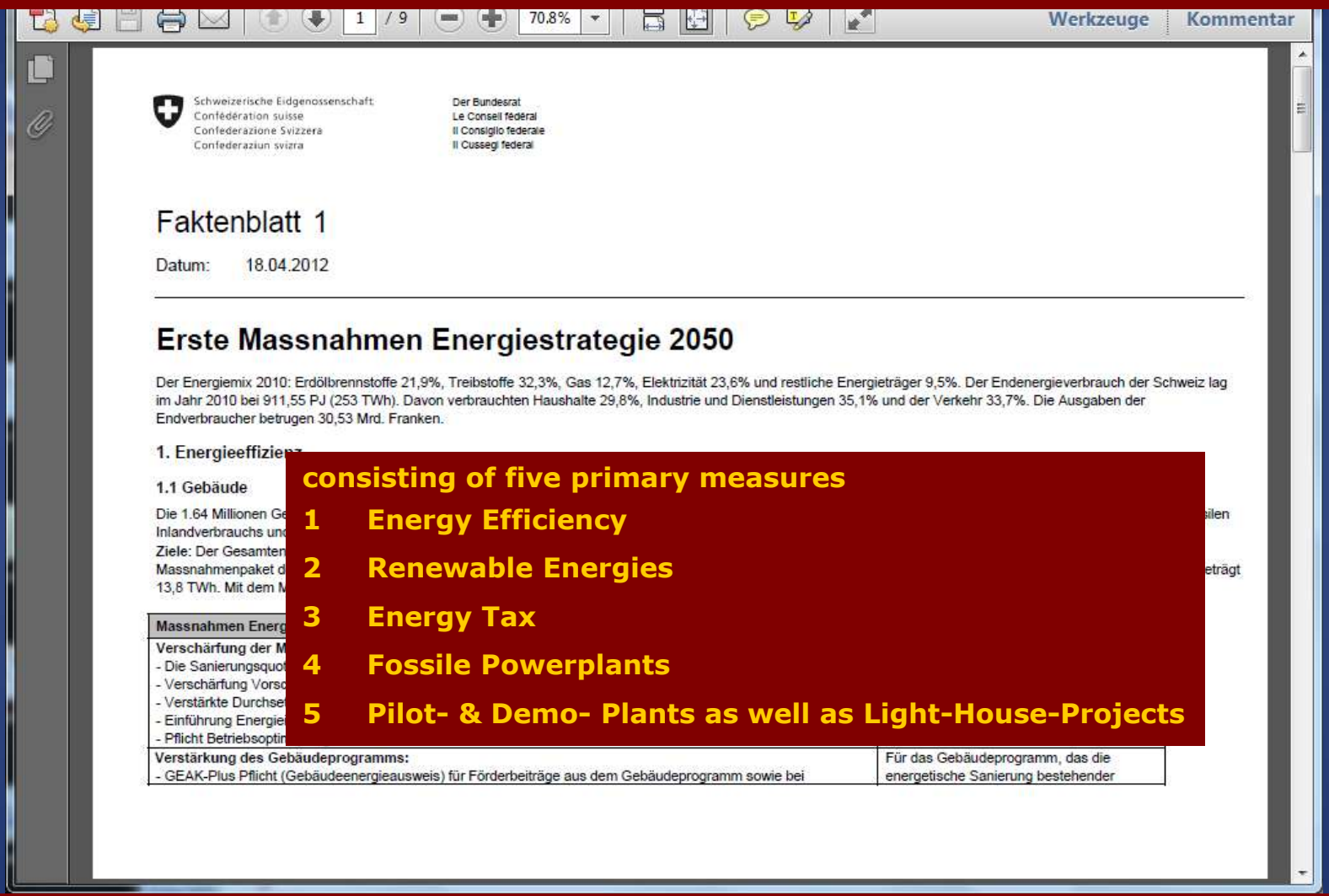
1 000 000 TeraJoule ≡ 1000 PetaJoule (PJ) ≡ **1 ExaJoule (EJ)** ≡ **280 TWh** *(weil 1 J = 2.78 10^{-4} Wh)*



Überblick über den Energieverbrauch der Schweiz im Jahr 2010 _Bundesamt für Energie BFE_Juni 2011

Implementation of **Energy Change** shall be mastered by **Energy Package 2050**

b) Energy Package 2050, as proposed by the Swiss Federal Council



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Der Bundesrat
Le Conseil fédéral
Il Consiglio federale
Il Cussegl federal

Faktenblatt 1

Datum: 18.04.2012

Erste Massnahmen Energiestrategie 2050

Der Energiemix 2010: Erdölbrennstoffe 21,9%, Treibstoffe 32,3%, Gas 12,7%, Elektrizität 23,6% und restliche Energieträger 9,5%. Der Endenergieverbrauch der Schweiz lag im Jahr 2010 bei 911,55 PJ (253 TWh). Davon verbrauchten Haushalte 29,8%, Industrie und Dienstleistungen 35,1% und der Verkehr 33,7%. Die Ausgaben der Endverbraucher betrugen 30,53 Mrd. Franken.

consisting of five primary measures

1. **Energy Efficiency**
2. **Renewable Energies**
3. **Energy Tax**
4. **Fossile Powerplants**
5. **Pilot- & Demo- Plants as well as Light-House-Projects**

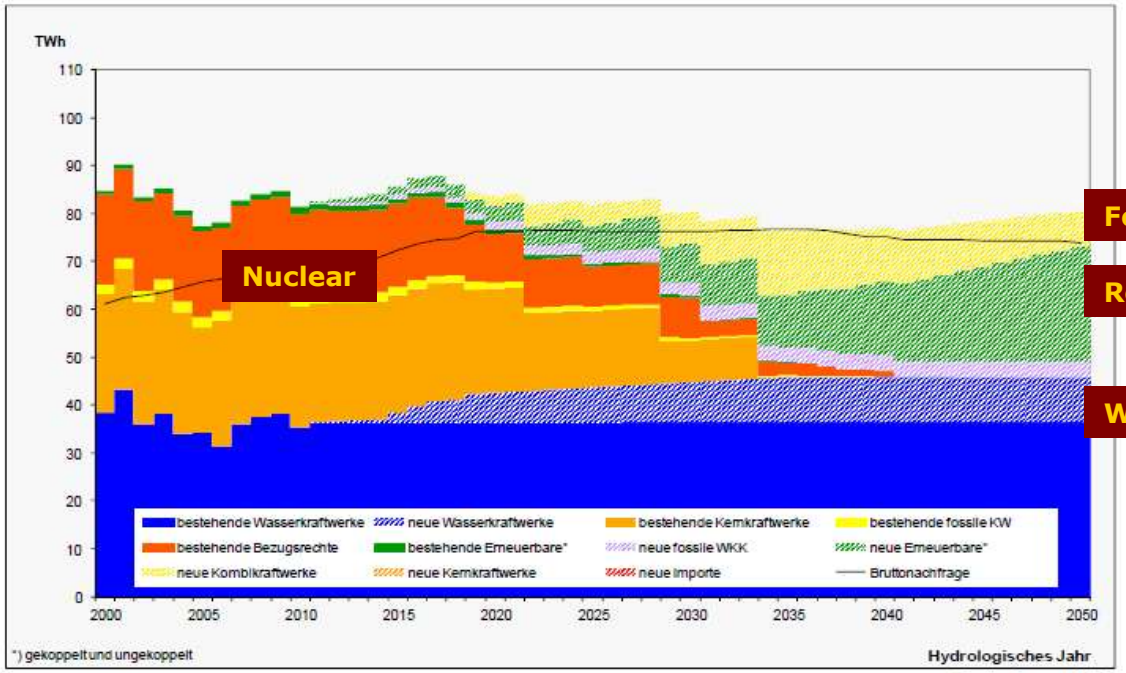
and what are the predicted **time curves** of **production,** n.b.: restricted to **power** only **?**

c) Forecasted DEVELOPMENT of Energy Mix until 2050

Energy Mix for **POWER Supply** only

Zusammensetzung des Stromangebotes

auf der Basis des Massnahmenpakets des UVEK (Quelle: Prognos)



Quelle: Prognos 2012

Energiestrategie 2050 – Pressekonferenz April 2012 3

Bundesrätin Leuthard

Fossil

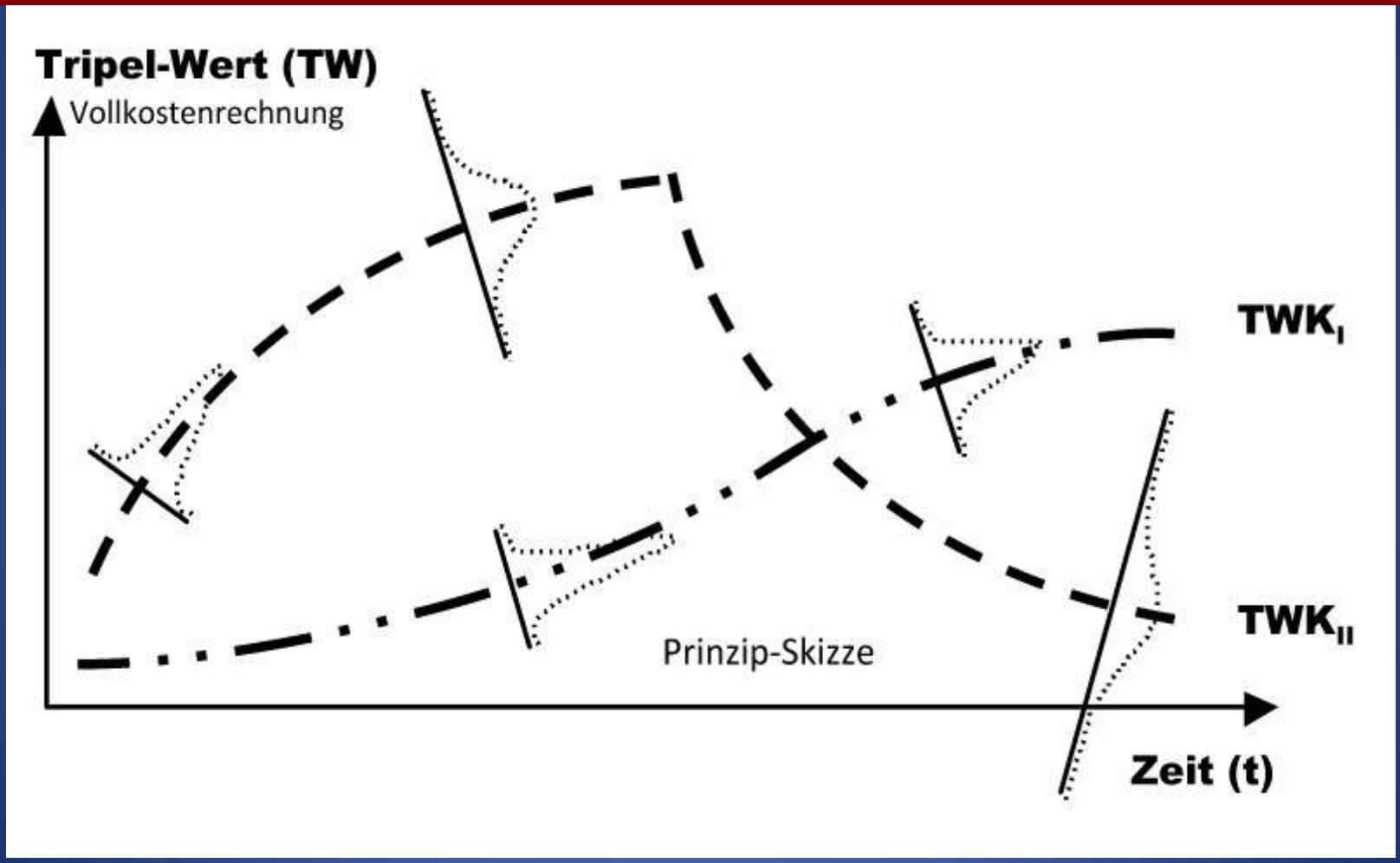
Renewables

Water

Nuclear

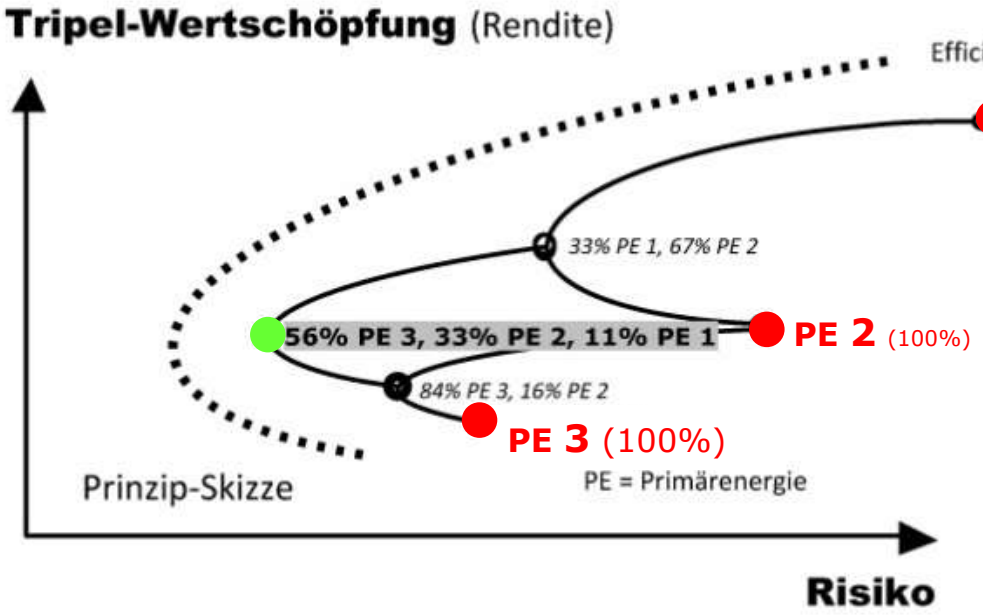
Question of interest: **What** is the **optimal mix** of the **renewables ?**

d) Optimal energy mix needs monetized Tripel Value Curves (TWK)



Optimal energy mix is provided by the **Portfoliotheorie (Markowitz)**

e) Optimal energy mix is provided by Portfoliotheorie (Markowitz)



Gegenüber 100% PE 3, der Primärenergie mit dem geringsten Risiko, hat der

optimale Mix :

56% PE 3, 33% PE 2, 11% PE 1

- ein **halb so grosses Risiko** bei
- einer **doppelt so hohen Wertschöpfung**

Certainly, Geoenergy will be a **dominant player** in the **optimal energy mix**

f) What **IMPORTANCE** might have **Geoenergy** for the **Energy Change**(*) ?

ENERGIEWENDE = **Ablösung nuklearer** und **fossiler** durch **erneuerbare** Primärenergien

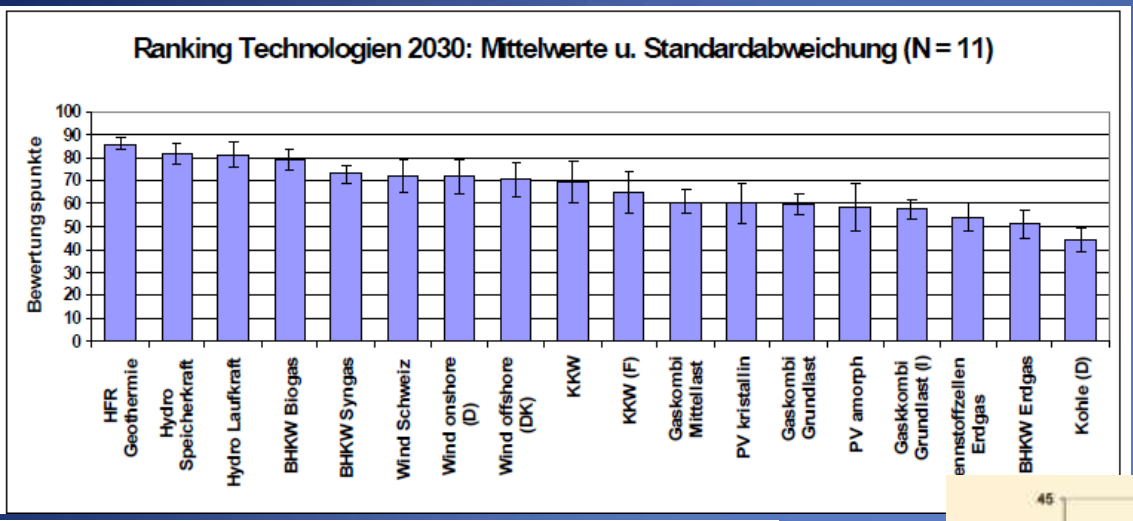
Realisierbarkeit der Optionen (grün)

Primär-Energie	STROM-Produktion Schweiz		Ablösung durch Zusatz-Potentiale realisierbar :								
	realisiert 2011 BFE, Tab.24 [1]		technisch maximal mit erprobter Technik Prognosen ATWS [2]	theoretisch wenn Vorkommen existent, doch mit erprobter Technik nicht nutzbar, dazu also **Innovation notwendig**			Kosten und Risiken				
				Innovation	Schweiz	Import	Kosten Innovation	Kosten HV-Netz & Speicherung	Tripel-Risiko	Break even	Pay-Back
	%	TWh	TWh		%	%	CHF				
fossil	4	3	Energie-wende: Ersatz	CO2-Sequestrierung	Energie-wende: 0	Energie-wende: 0	> 10 Mia.[3]	Devisenexport			
nuklear	41	26		- 4. Generat. - Fusion			> 100 Mia.	> 10 Mia.			
total		**29**									
Wasser	54	34	2	erschöpft	0	0		> 10 Mia.			
Sonne	0.2	0.15	15	à la Desertec	0	> 370	> 10 Mia.	> 10 Mia.			
Wind	0.1	0.07	4	Swimming Mega-Parks	0	> 370	> 10 Mia.	> 10 Mia.			
Boden	0	0	3	Non-abrasive Drilling	> 370	0	< 10 Mia.	0			
Bio	0.7	0.42	4	Förderinitiative BioProFi [4]	0	< 370	< 10 Mia.	> 10 Mia.			
total	**100%**	***64 TWh***	***29***	(*) **370**% = 237 TWh = **Gesamt-Energieverbrauch** (=Strom, Wärme, Mobilität) Schweiz/2011 Tab.1[1]							

(1) *Bundesamt für Energie Schweizerische Gesamtenergiestatistik 2011,*
(2) *www.akademien-schweiz.ch/.../Zukunft_Stromversorgung_Kurzfassung*
(3) *[PDF] 000000290408 - Bundesamt für Energie BFE, S.9*
(4) *http://www.bmbf.de/foerderungen/16947.php*

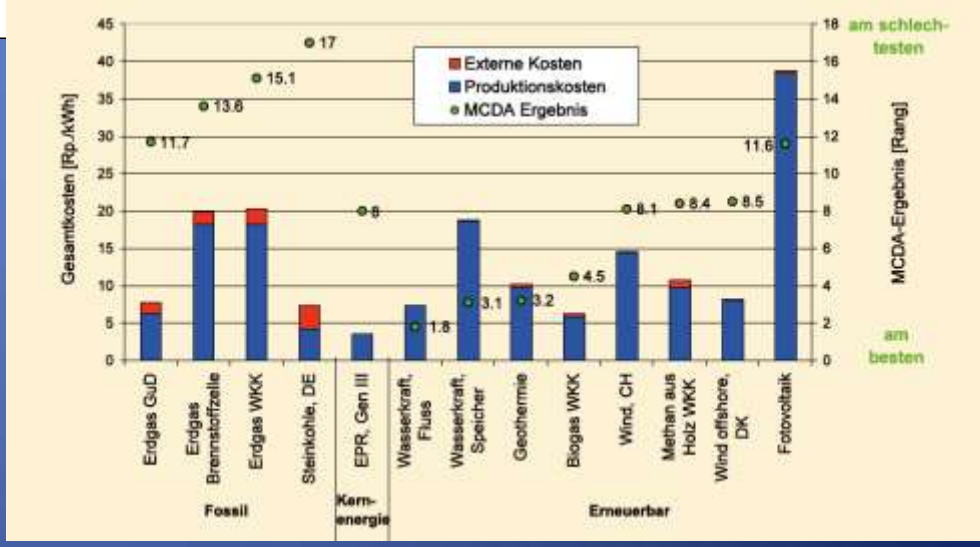
Geoenergy must have an **utterly strong position** in the **optimal energy-mix**

a) Sustainability ranking of Geoenergy - Results of EARLIER studies



Energie Trialog Schweiz, Dez. **2008**
www.energietrialog.ch/cm_data/Renn_MCDA_Workshops_2008.pdf

PSI - Energie-Spiegel, Nr. 20, Juni **2010**
gabe.web.**psi**.ch/pdfs/**Energiespiegel**_Nr20_07**2010**_d.pdf

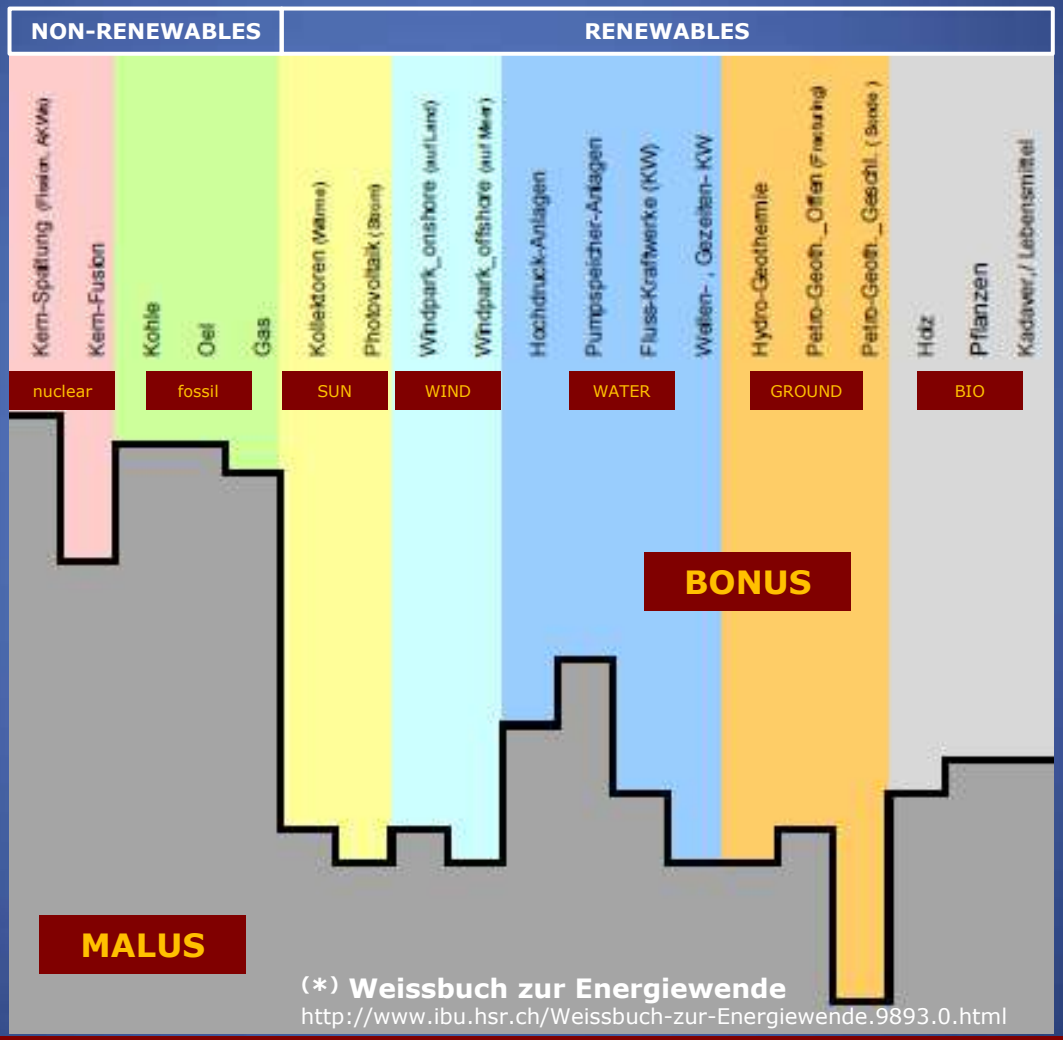


In both studies, the qualification of the primary energies concerning **sustainability** is performed by the so called **MCDA (Multi-Ctriteria Decision Analysis)**, as explained in:
http://www.satw.ch/publikationen/schriften/stromversorgung/index

in both studies: **GEOENERGY is ranked very high**

III) QUALIFICATION of Geoenergy

a) Sustainability ranking of Geoenergy - Results of RECENT inquiry(*)



Even **post Fukushima: GEOENERGY is again ranked highest**

IV) ASSETS of Geoenergy
"The Potential of *Deep Geothermal Energy* in the Energy Debate"

The **potential** of "Deep Geothermal Energy" (Geoenergy) is **extraordinarily high :**

- **Theoretically**, the potential is unlimited

- **Politically**, the decisive assets of deep geothermal energy are the following **facts:**
  - **autonomy**, because anywhere existent
  - thus, **high supply security** of energy (power and heat)
  - **no cost** for ressources, hence no export of currencies
  - **negligible GAU** (maximum credible accident)
  - **no earthquakes**, when CLOSED heat exchanger,
  - **no dangerous emissions**, no waste to be disposed
  - high **social acceptance**, thus, democratic support

- **Technically**, the potential

  - **depends on** the **CAPABILITY of accessing and exploiting** the so most interesting **unlimited occurrence** of geothermal energy

  - is limited to the **economic feasibility of such access and exploitation** by **necessarily new technologies** for deep drilling, as by **photonics**

Therefore, **new drilling techniques,** based on **Photonics**, will be presented as next