

Willkommen  
Welcome  
Bienvenue



## **Science in support of climate change policy: what can research provide?**

16<sup>th</sup> Global Change Day, April 1, 2015

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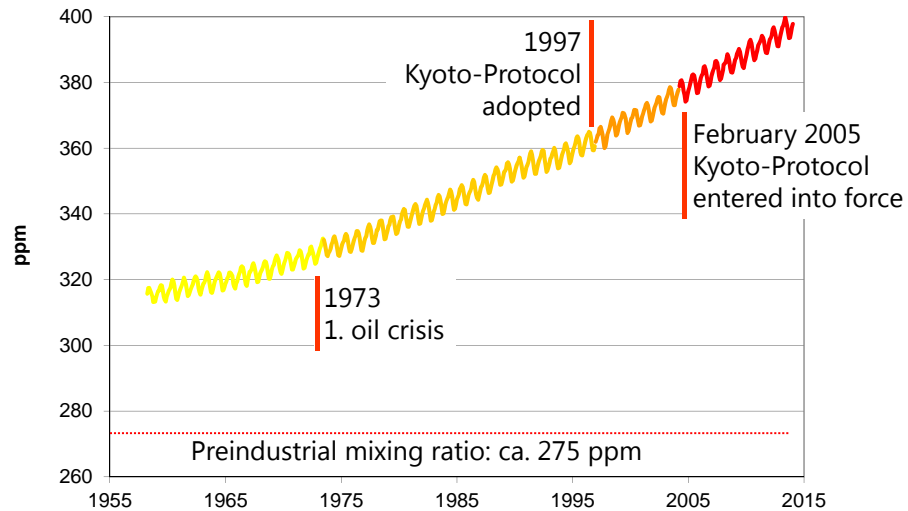
### Content



- Introduction
- Observations
- Demonstration action
- Outlook

## Carbon Dioxide

### - Change of mixing ratio



Quelle: Dr. Pieter Tans, NOAA/ESRL (<http://www.esrl.noaa.gov/gmd/ccgg/trends/>)

## Observations started 40 years ago

### - an obligation to reduce pollutants



#### Internationale Zusammenarbeit

20. März 1972  
E/Pr/DG



**Weiträumige Verfrachtung luftfremder Stoffe durch die Atmosphäre**

- ..... die Schweiz hat sich gegenüber der OECD verpflichtet
- ..... im Rahmen eines internationalen Messprogrammes
- ..... Weiträumige Verfrachtung luftfremder Stoffe durch die Atmosphäre
- ..... zwei Messstationen, wovon eine im Gebirge,

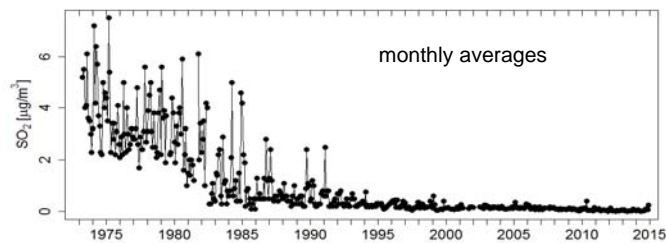
Aus Brief 20. März 1972

## Long-term time series

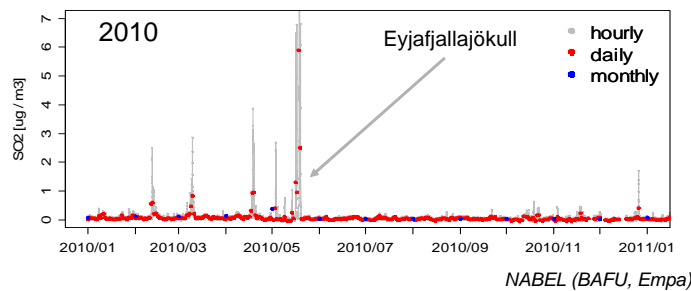
- to support international protocols



### Sulfur dioxide @ Jungfraujoch



Detection  
Composition  
Change



Event  
Analysis

NABEL (BAFU, Empa)

## Abatement of Transboundary Air Pollution



### General principles

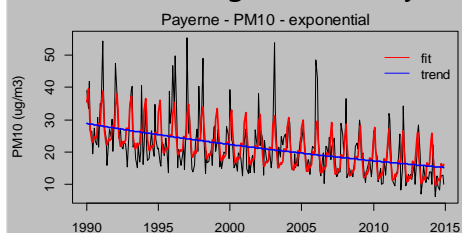
UNECE Convention on Long-range Transboundary Air Pollution (signed 1979)



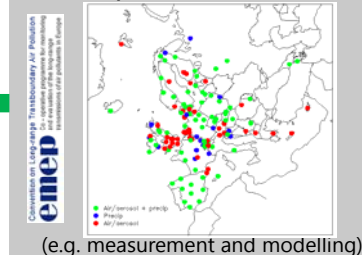
### Specific measures

**Defined in protocols**  
e.g. Gothenburg protocol to Abate Acidification, Eutrophication and Ground-level Ozone

### Assessment (e.g. trend analysis)



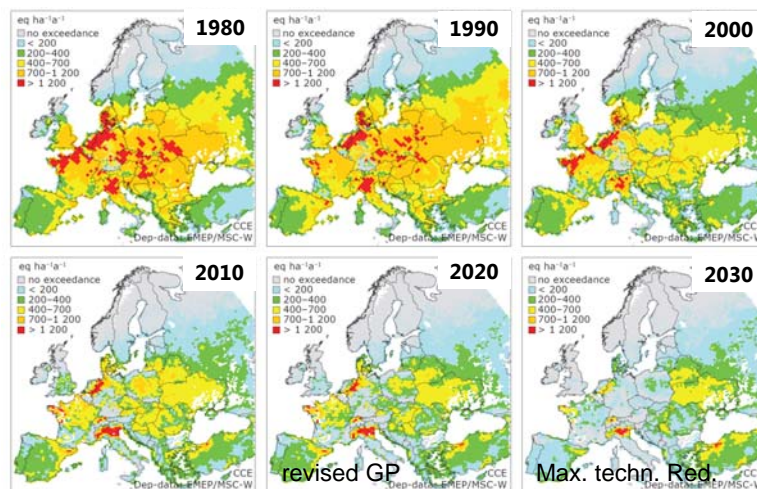
### Implementation



## Protocols to the Convention

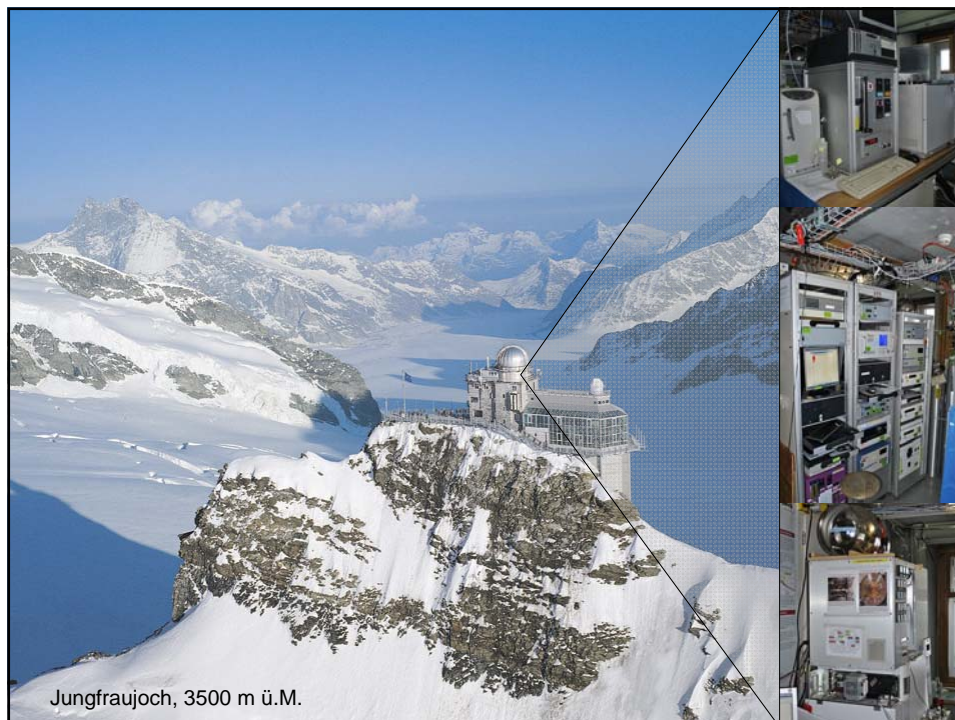
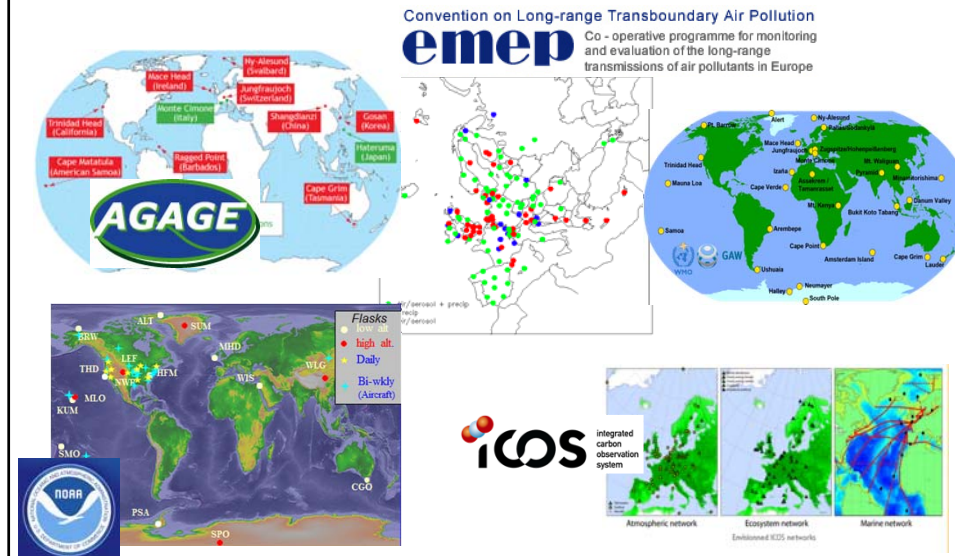
1984	Protocol on Long-term <b>Financing</b> of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP);
1985	Protocol on the <b>Reduction of Sulphur Emissions</b> or their Transboundary Fluxes by at least 30 per cent
1988	Protocol concerning the <b>Control of Nitrogen Oxides</b> or their Transboundary Fluxes
1991	Protocol concerning the Control of Emissions of <b>Volatile Organic Compounds</b> or their Transboundary Fluxes
1994	Protocol on <b>Further Reduction of Sulphur Emissions</b>
1998	Protocol on <b>Heavy Metals</b>
1998	Protocol on <b>Persistent Organic Pollutants</b> (POPs);
1999	Protocol to Abate <b>Acidification, Eutrophication and Ground-level Ozone</b> , "Gothenburg Protocol" (GP); revised in 2012

## Areas of Critical Loads of Eutrophication by nitrogen emissions decline **Success of UNECE - Convention**

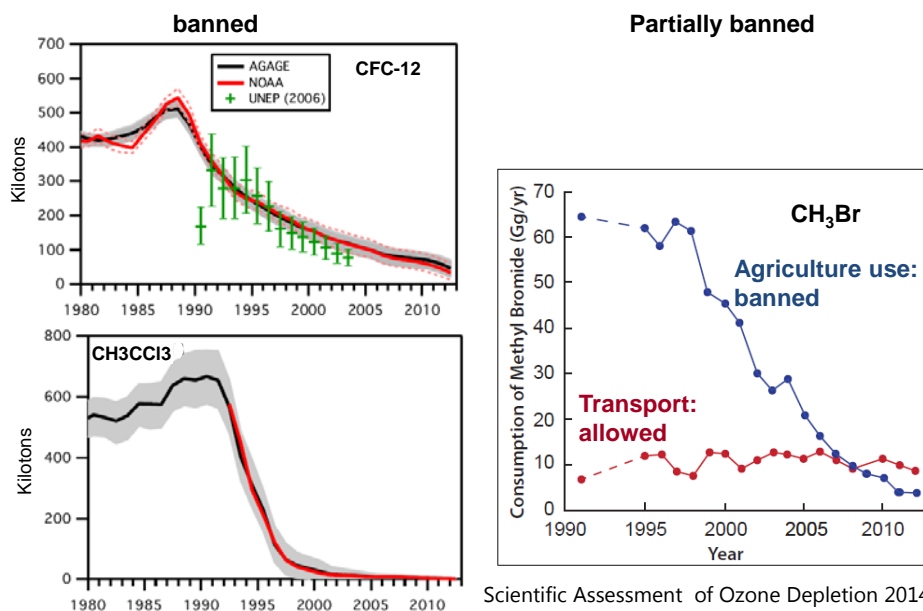


Effects of air pollution on European ecosystems, EEA 2014

## Global and Regional Networks

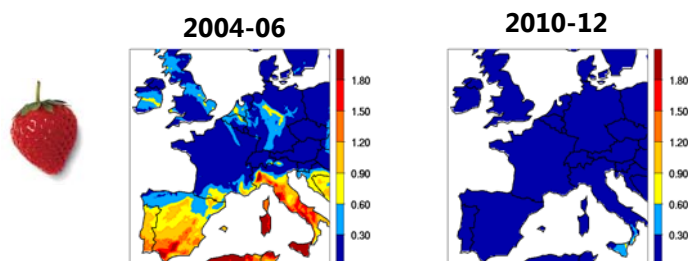


## Emissions of Cl- and Br- containing substances



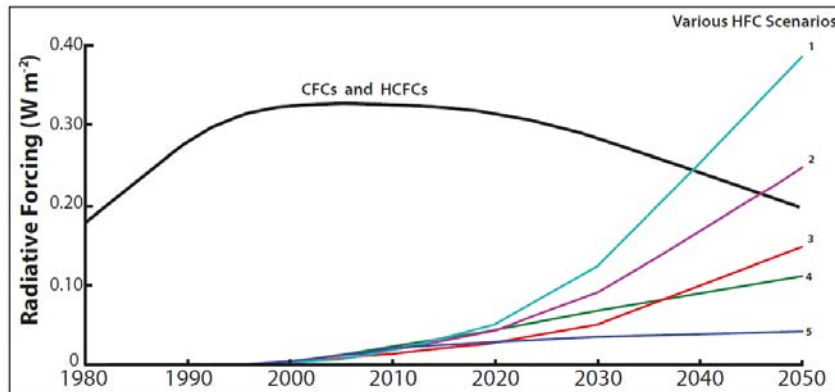
Scientific Assessment of Ozone Depletion 2014

## Source Identification of CH<sub>3</sub>Br in Europe Forbidden since 2008



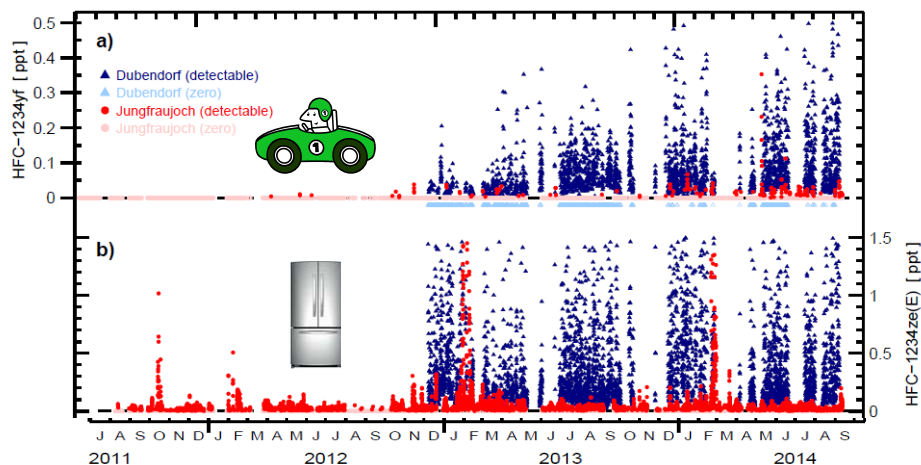
Reimann et al.

Radiative forcing from controlled ODSs  
and their substitutes has stabilized  
over the past two decades  
**Success of Montreal Protocol**



Scientific Assessment of Ozone Depletion 2014

New Compounds – early warning  
"HFC-1234yf/HFC-1234ze(E):

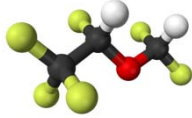


Vollmer et al., Environ. Sci. Technol. 2015, 49, 2703–2708, DOI: 10.1021/es505123x

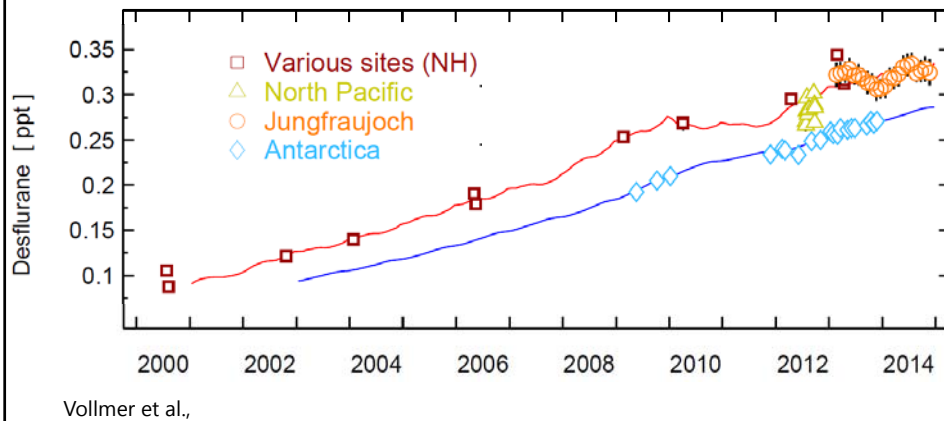


## Desflurane

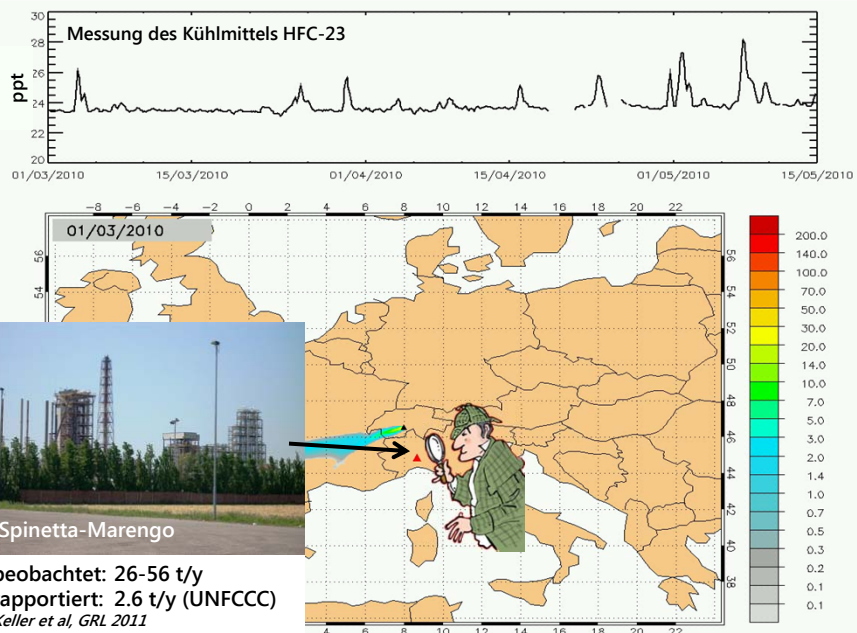
2-(difluoromethoxy)-1,1,1,2-tetrafluoro-ethane



Lifetime: 14 yr  
GWP: 2540  
Med Intro, ca. 1995

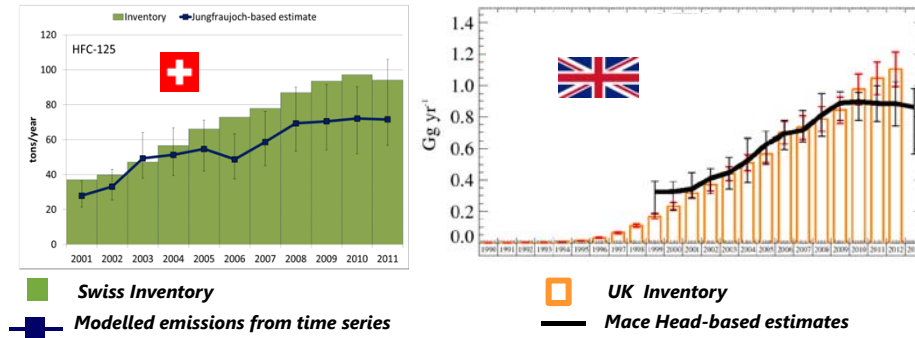


## Source Identification



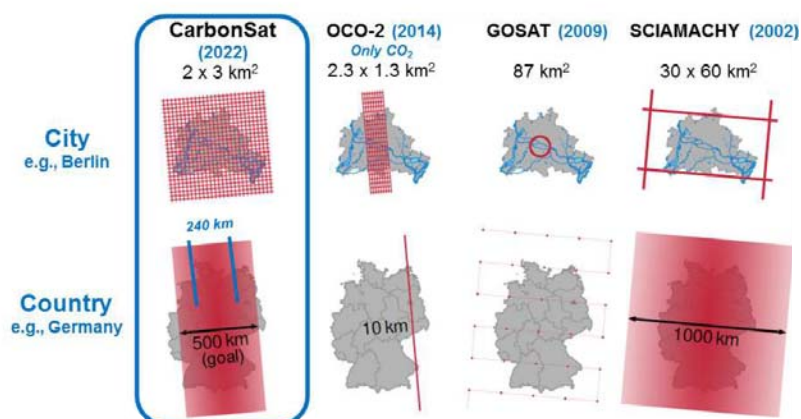


## Independent Emission Estimation – compliance of international treaties



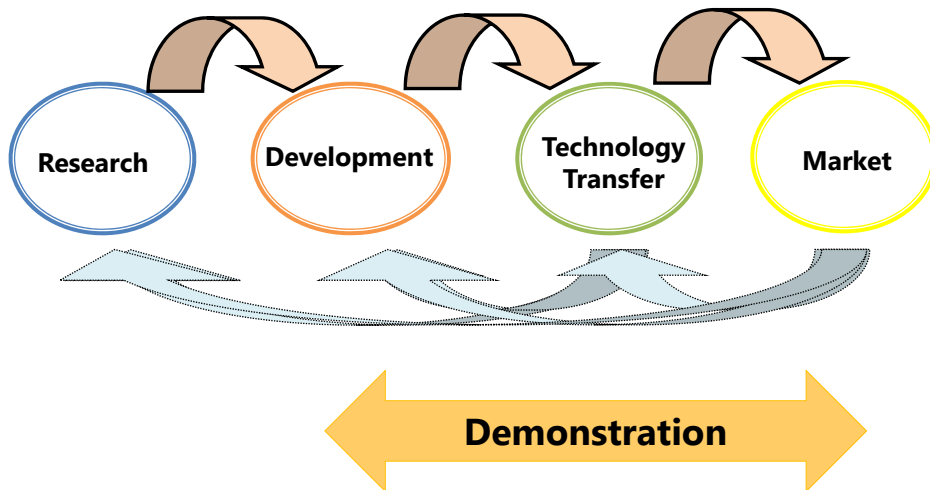
Independent method of emission estimation  
for future protocols

## Continuous Observations

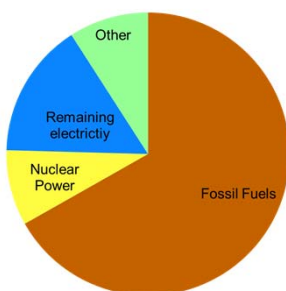


Bernd Sierk et al. *Proc. SPIE* 9218, Earth Observing Systems XIX, 92181F  
(September 26, 2014); doi:10.1117/12.2061930

What do we need?

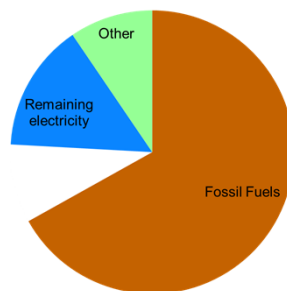


## Challenges of the Future



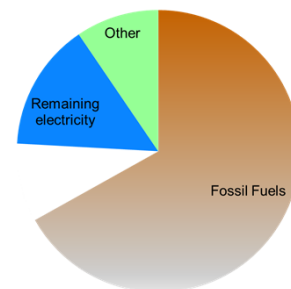
Final Energy Use CH 2012  
Schweizerische Energiestatistik 2012, BfE

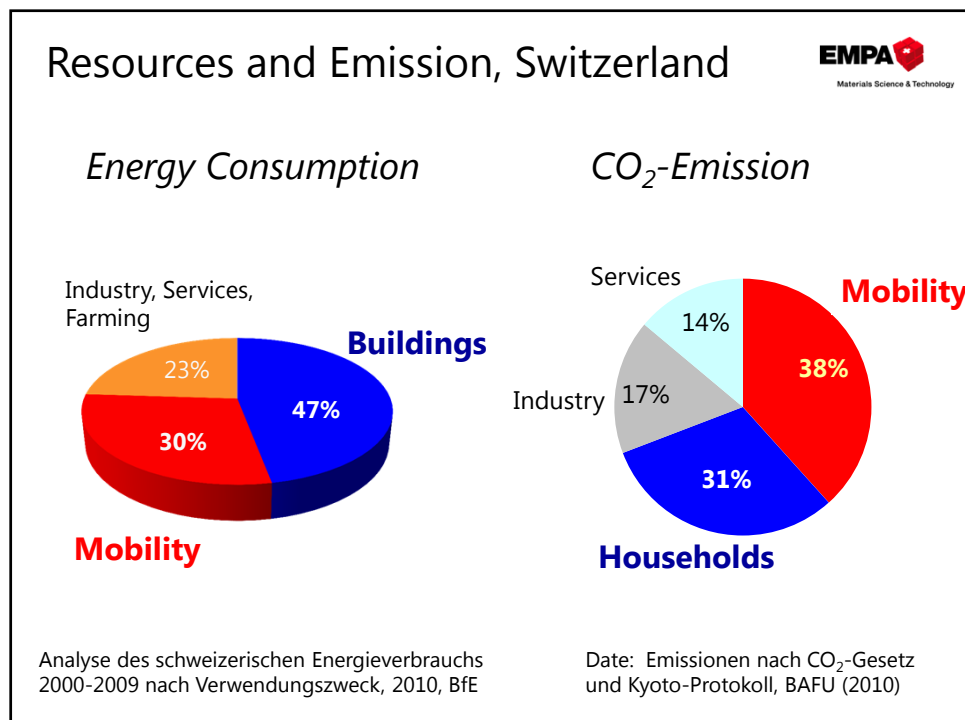
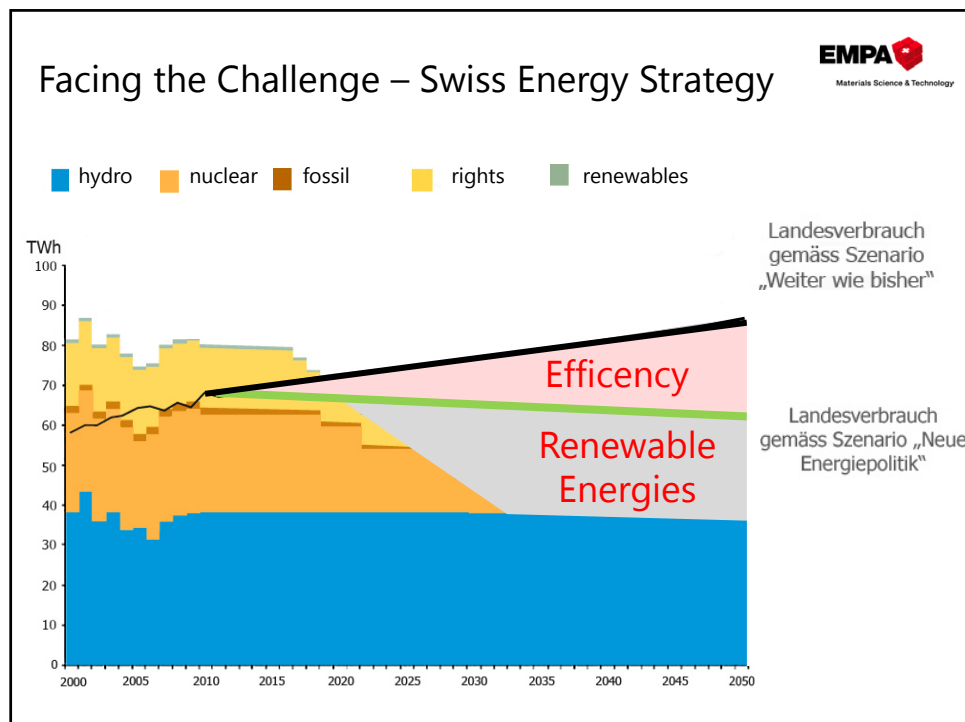
Nuclear  
phaseout  
2019 - 2034



Reduction of the emission  
of green house gases

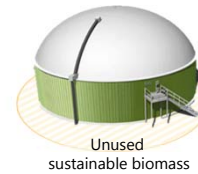
Reduction of the  
dependence on  
foreign countries  
regarding  
energy supply





## Renewable fuels

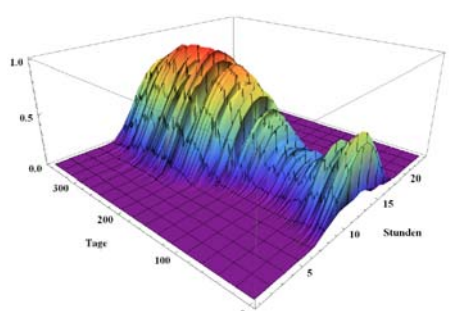
### *Unused sustainable biomass*



Switzerland has 2 - 11 TWh/a unused, sustainable biomass that could be largely converted into biogas.  
(B. Steubing et al., 2010)

## Mega-Trend in the energy sector

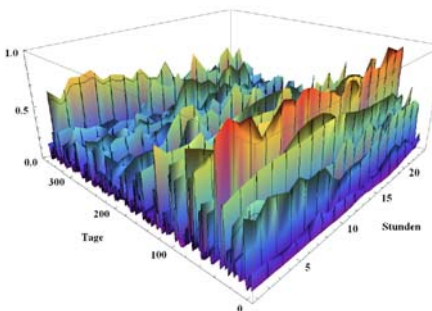
### *Fluctuating energy flows (sun + wind)*



**Photovoltaic**

Excess electricity in summer

Quelle: Prognos 2012



**Wind energy**

Stochastic Production

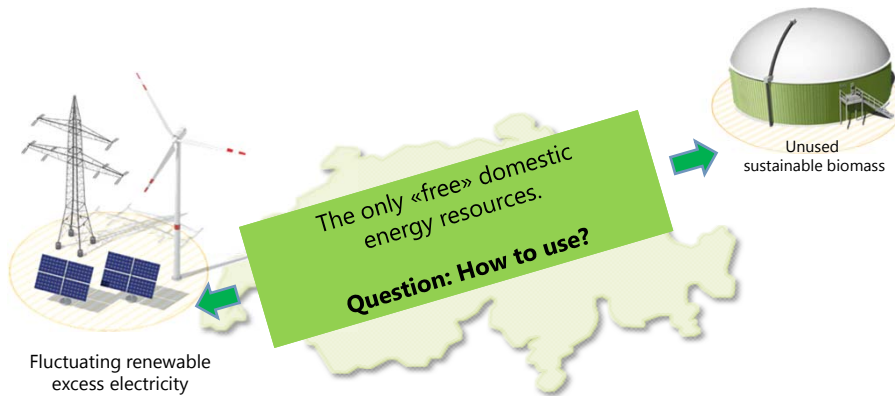
Quelle: Prognos 2012

### **Simulation of electricity supply 2050 (Prognos)**

- Approx. 15 TWh strongly fluctuating electricity
- 9 TWh excess electricity (summer), if CHP/CCP are not controllable
- 4.5 TWh excess electricity (summer), if CHP/CCP are controllable

## Renewable fuels

### *Fluctuating renewable excess electricity*

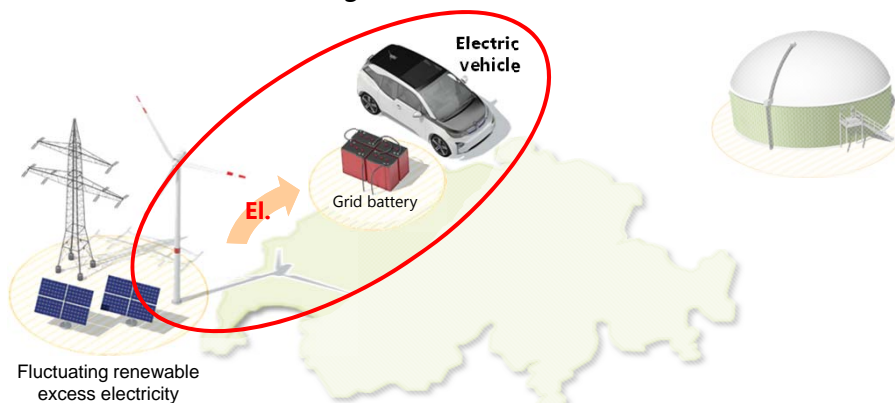


Until 2050, the new Swiss energy strategy leads to **4.5 – 9 TWh/a** renewable excess electricity in the summer. (Prognos 2012).



## Renewable fuels

### *Electro-chemical storage with use in electric vehicles*

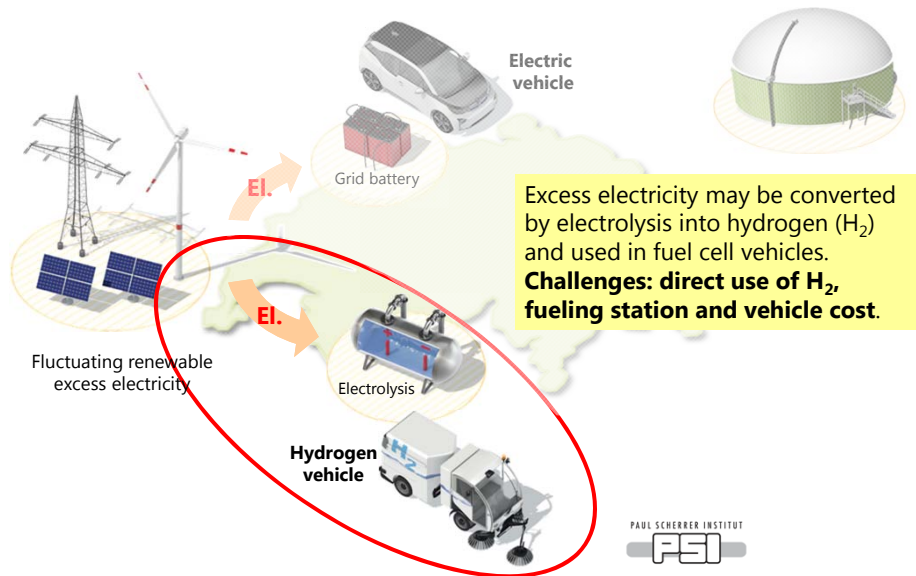


Excess electricity may be stored in grid-batteries and be used for the charging of battery electric vehicles.  
**Challenges: Energy- and vehicle costs, winter operation with renewable electricity.**



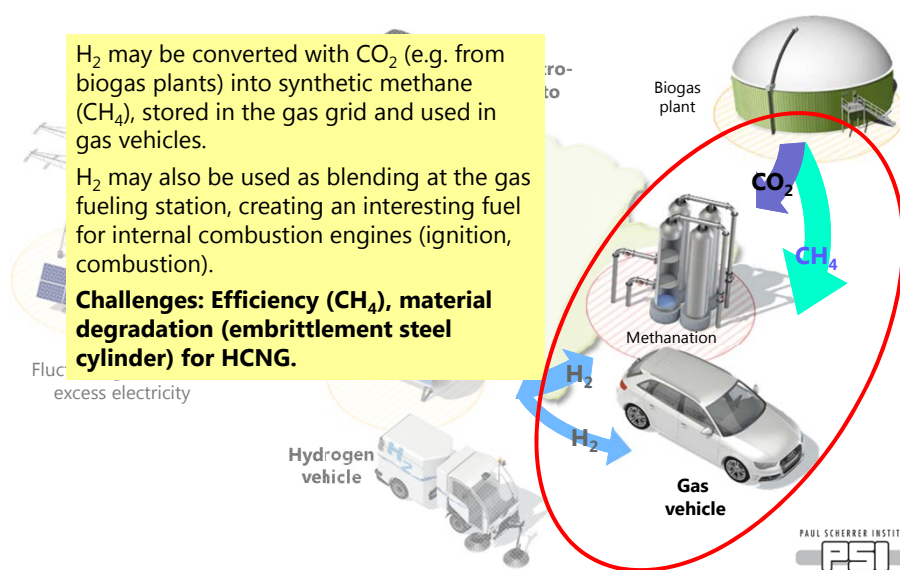
## Renewable fuels

### Chemical storage with use in $H_2$ vehicles



## Renewable fuels

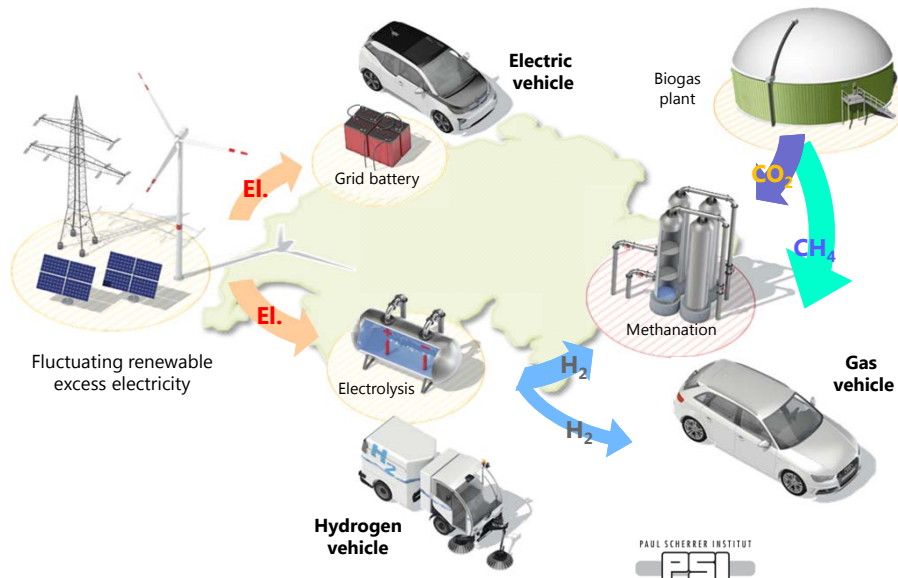
### Chemical storage/methanation and use in gas vehicles





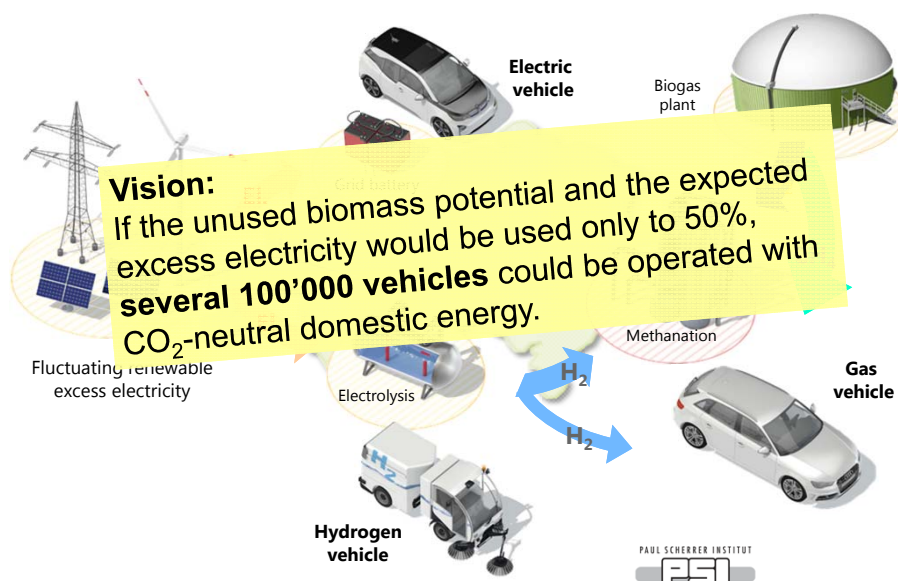
## Renewable fuels

*Diversification in the vehicle powertrain concepts and fuels*



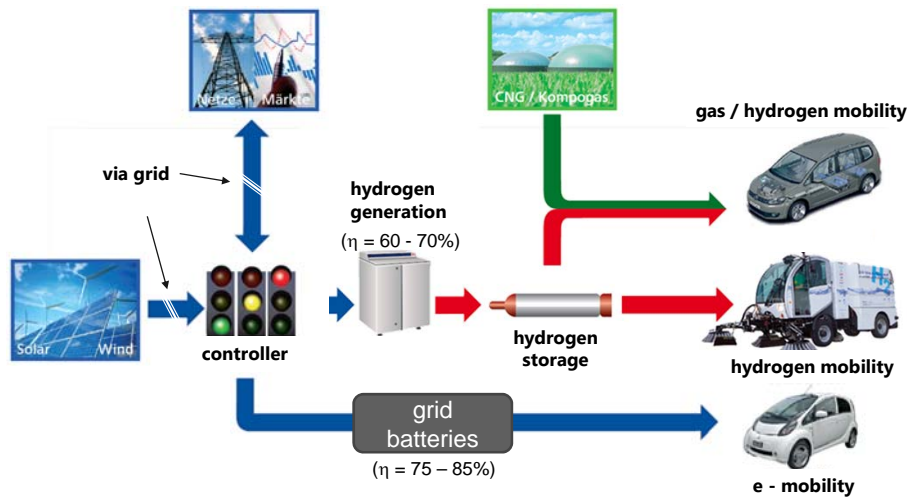
## Renewable fuels

*Diversification in the vehicle powertrain concepts and fuels*



## Future Mobility Demonstrator @ Empa

Renewable clean energy for a sustainable mobility



A joint Research and Technology Transfer Platform (RTTP) in the ETH-domain

## Conclusions



### Long-term observation is crucial

- to detect changes of atmospheric composition
- to assess trends of pollutants and greenhouse gases

### Modelling of processes is essential

- to understand atmospheric processes
- to verify independent emissions
- to support national and international policy

### Demonstrating new approaches is vital

- to make the change happen

we need

Reliable, long-term observation to support  
international treaties

Implementation of new technical approaches  
to demonstrate the reduction of GHGs

Supporting political regulation