

Hydrogen as a future energy sources

One fuel for everyone – and everything

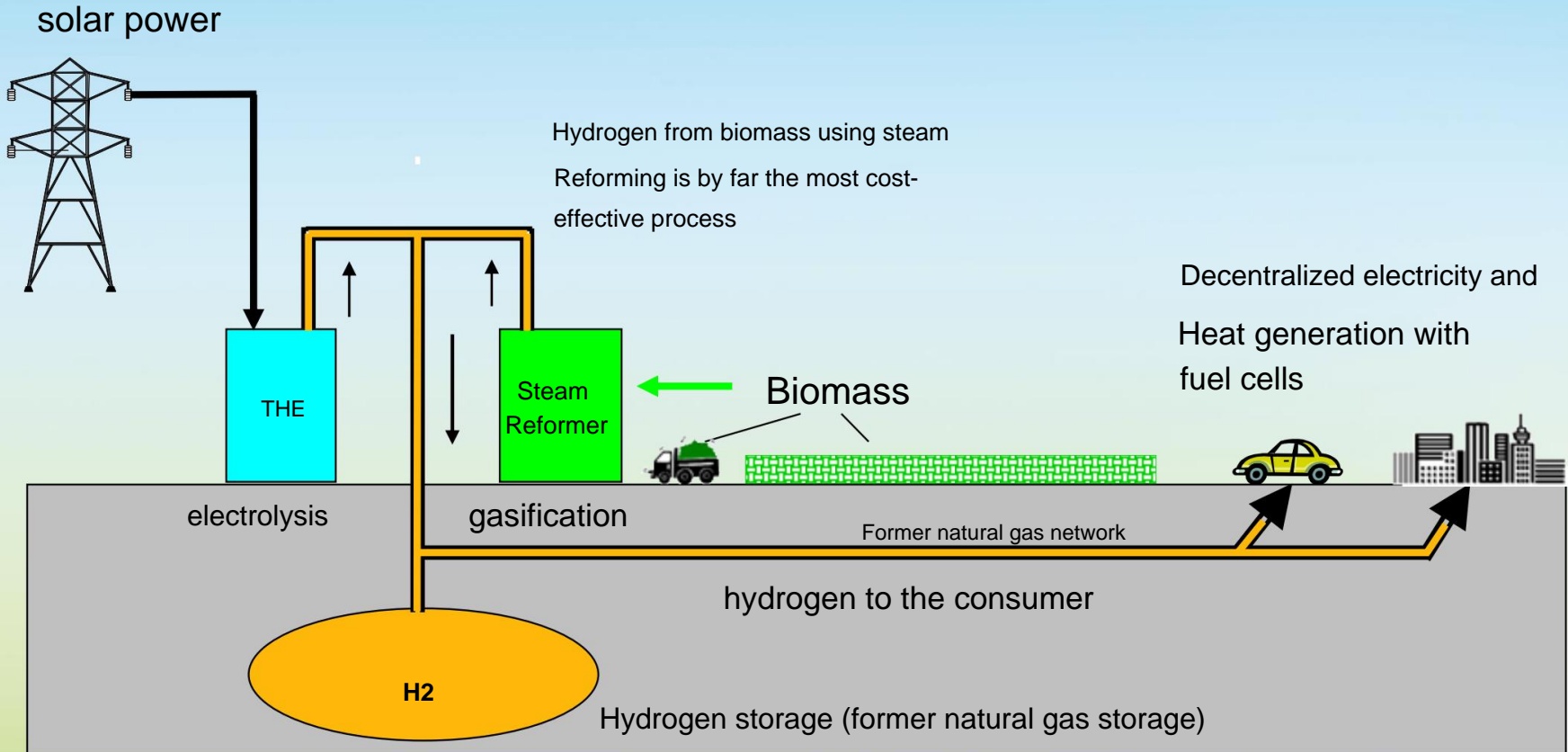
Darmstadt University of Applied Sciences, November 11,
2010 Karl-Heinz Tetzlaff tetzlaff@h2-patent.eu



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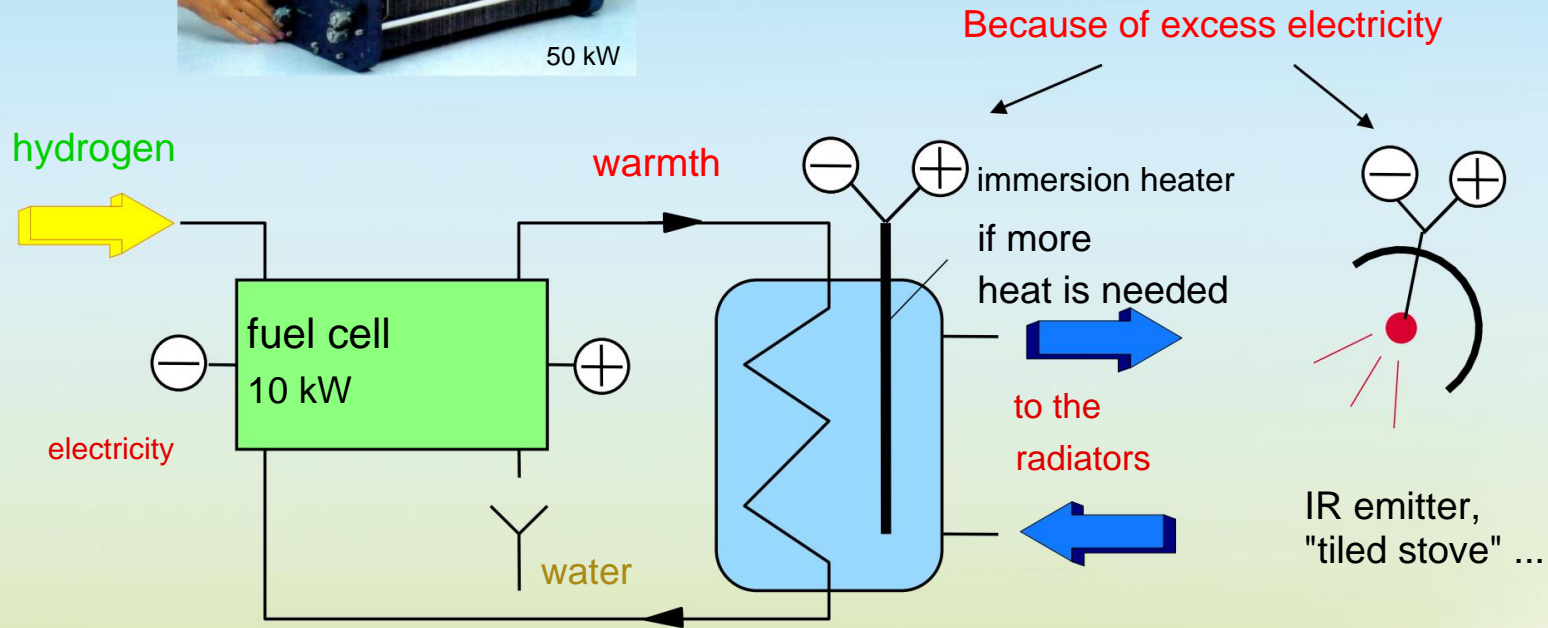
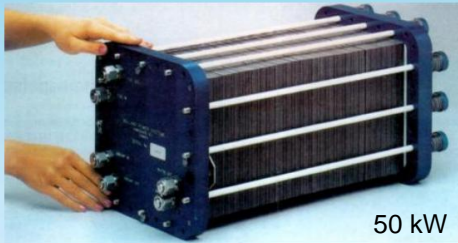
True Green Hydrogen Economy:

hydrogen to the end user



- System-related excess electricity, therefore
- Heat-controlled energy **management without energy losses**

fuel cell heating hydrogen



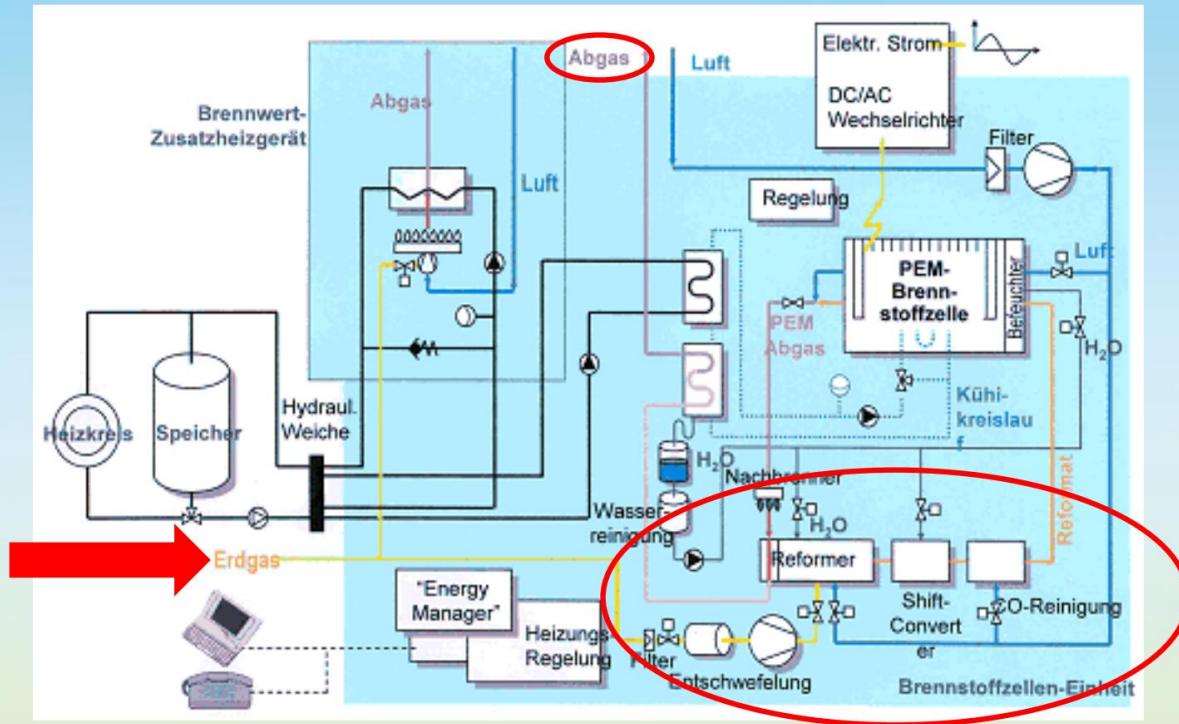
The fuel cell has the function of a burner that converts the hydrogen into electricity and heat in equal parts.

Rooms are only electrically heated when required.

Fuel cell systems cost about 50 €/kWel for mass production of 100,000 units. A service life of 100,000 hours is expected. (Final Report Roads2HyCom 2009)



The so-called fuel cell heating



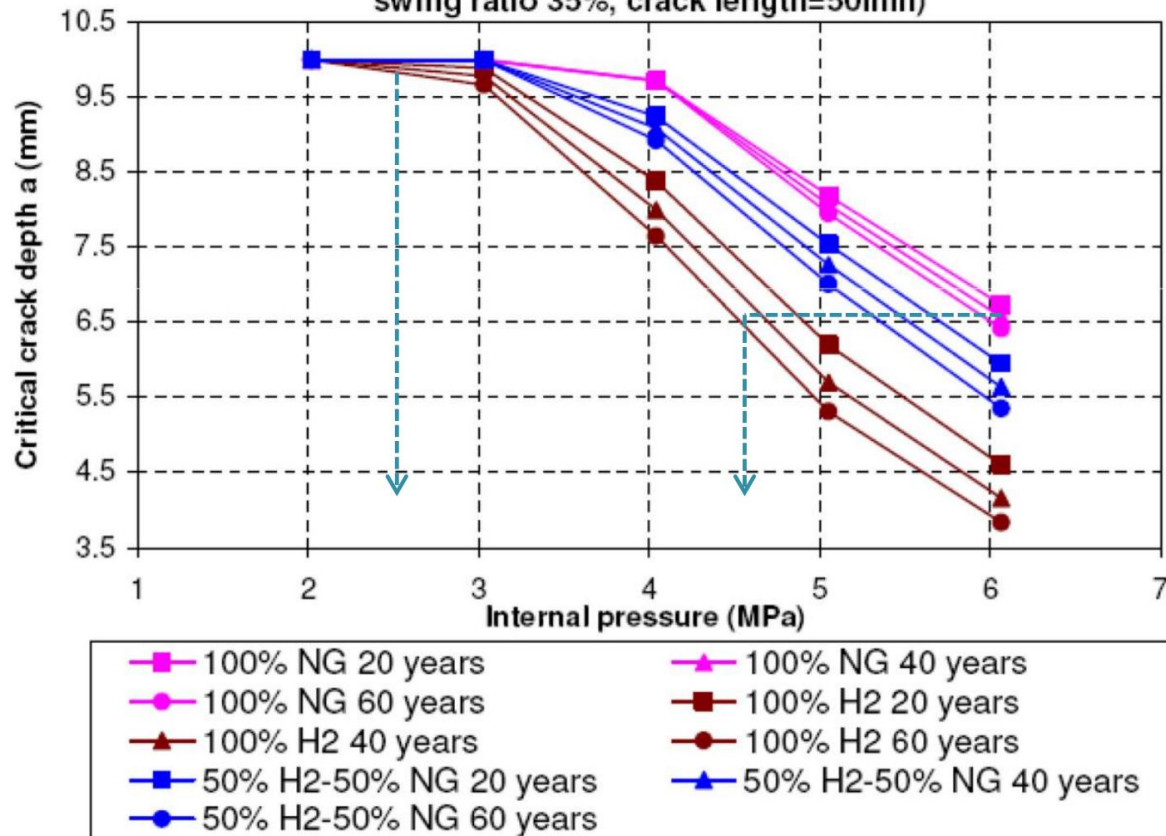
In "published opinion" fuel cell heating is actually an expensive combination of a hydrogen factory and the actual fuel cell in the natural gas grid. The concept has the following features:

- low maximum efficiency (25%)
- limited controllability (at partial load of 25% "the stove goes out")
- Sluggish response requires connection to a power grid

A real fuel cell heating system is connected to a hydrogen network, can follow any load demand instantaneously with a high level of efficiency (60%) and therefore does not require a network connection

Hydrogen in natural gas pipelines

Critical initial crack depth a v.s internal pressure (X52, pressure swing ratio 35%, crack length=50mm)



Source: DBIGUT ; from NATURALHY final report 2009

Consequences for X52:

pressure reduction by 25%,
or addition of 500 ppm O₂ ,
or shortening of
Inspection interval

A hydrogen economy, on the other hand, is a regional gas economy where pressures over 2.5 MPa (25 bar) are not required. Even with this very brittle steel, hydrogen embrittlement is unacceptable

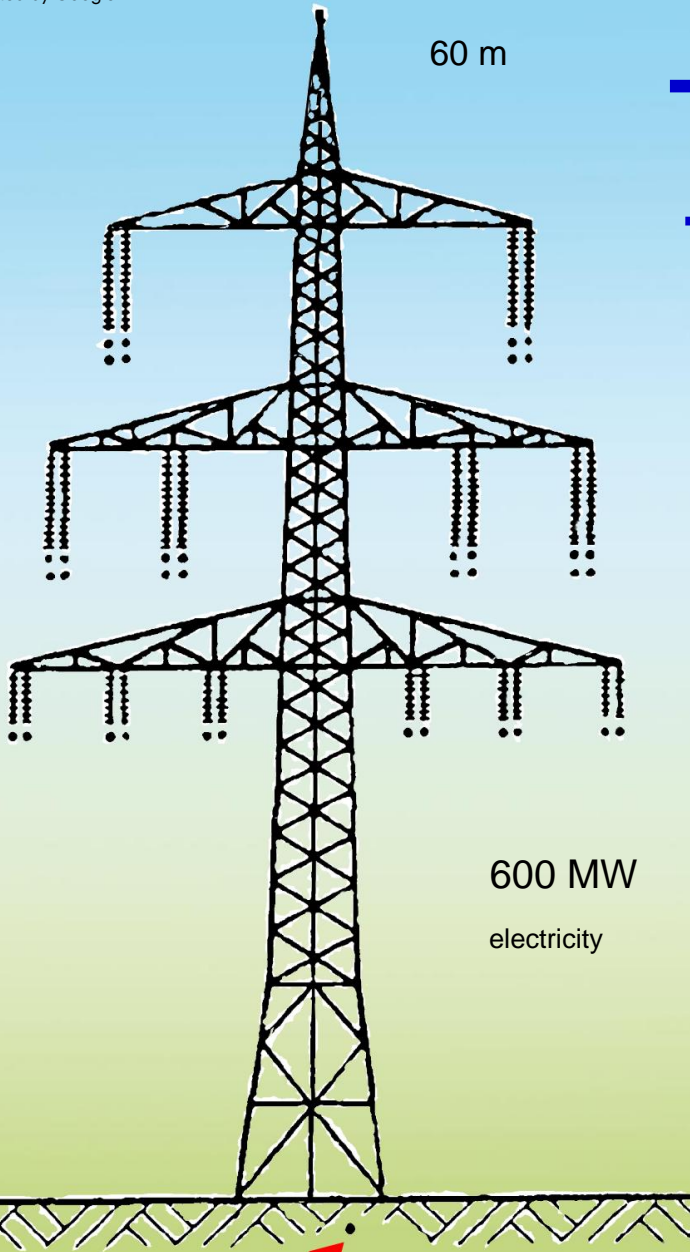
expect.

When the natural gas network is converted to hydrogen, the Leakage losses from 0.1% to 0.04% of the amount of energy transported



60 m

Transportation costs from farm to household



600 MW
electricity

Hydrogen = 0.7 ct/kWh = 9.3 ct/
electricity kWh (approved for 2009)

Examples of electricity costs:

Electricity from own fuel cells = 3 + 0.7 =
3.7 ct/kWh

Electricity from *decommissioned nuclear reactors*
= 2 + 9.3 = 11.3 ct/kWh

Desert electricity (DESERTEC)
6 + 3 + 9.3 = 18.3 ct/kWh

600 MW hydrogen
(pipeline drawn to scale)



recipe

Biomasse + H₂O \rightarrow **H₂** + CO₂



Wood:

$C_6H_9O_4 + 8 H_2O \rightarrow 6 CO_2 + 12,5 H_2$ (allotherm)

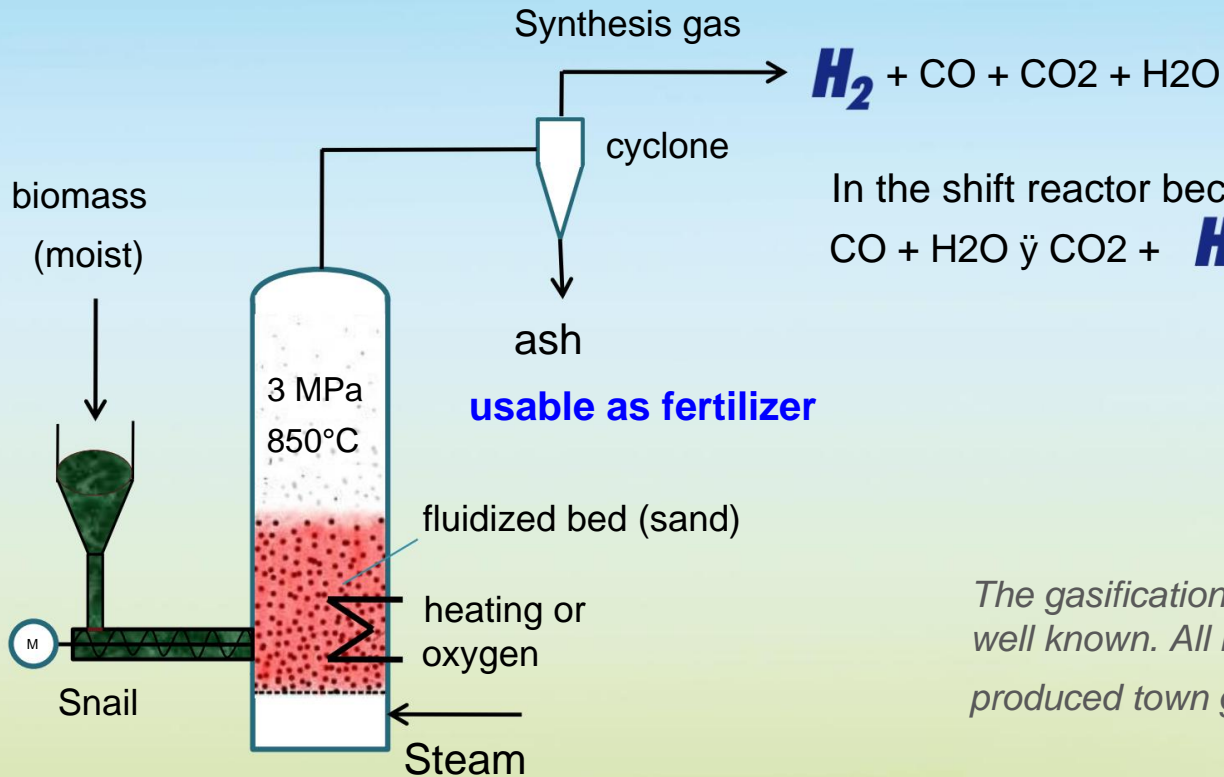
$C_6H_9O_4 + 1,1 O_2 + 5,8 H_2O \rightarrow 6 CO_2 + 10,3 H_2$ (autotherm)

that. 850°C

It is an endothermic energy conversion in which, in principle, no energy losses occur.



State-of-the-art H₂ production

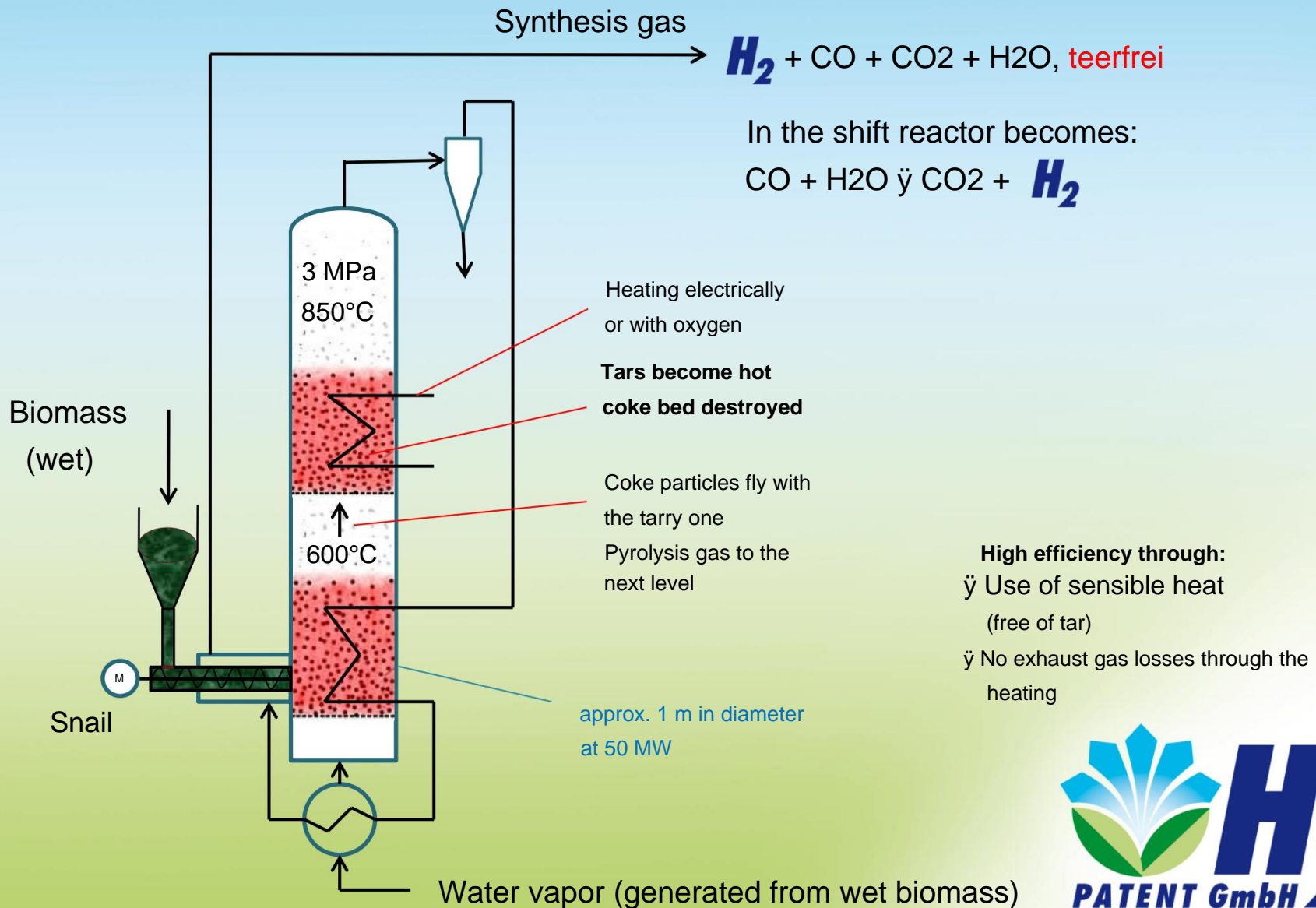


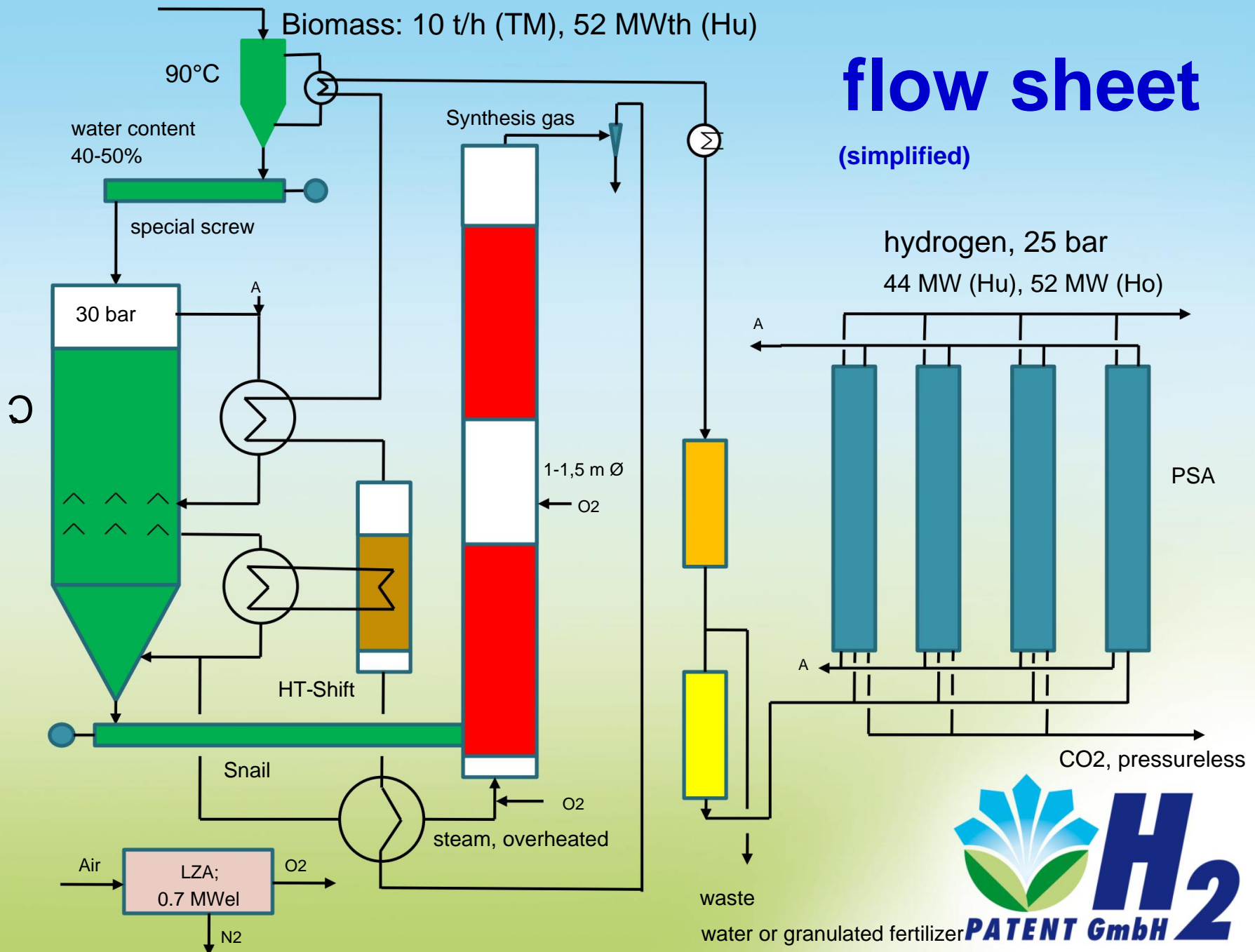
The gasification process itself is well known. All industrial nations have produced town gas from coal in this way.

Steam-Reformer



Steam-Reforming innovativ



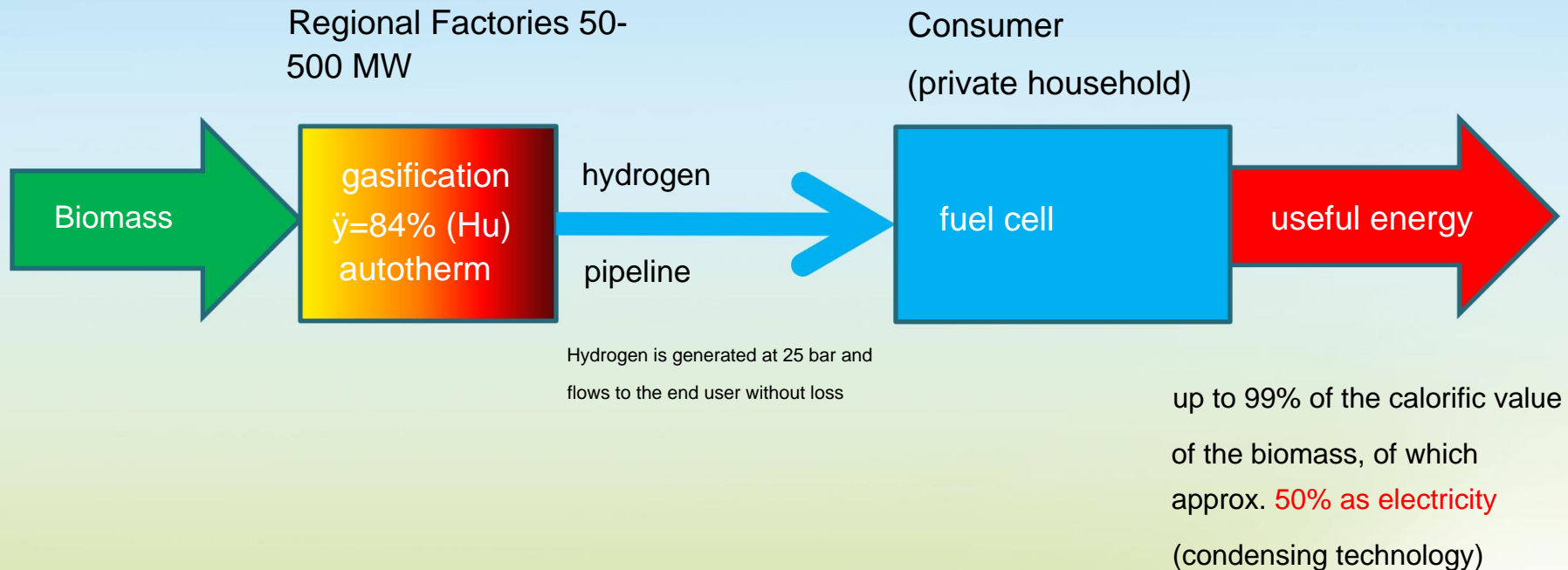


Comparison: biological/thermochem



projection

efficiency of the energy chain

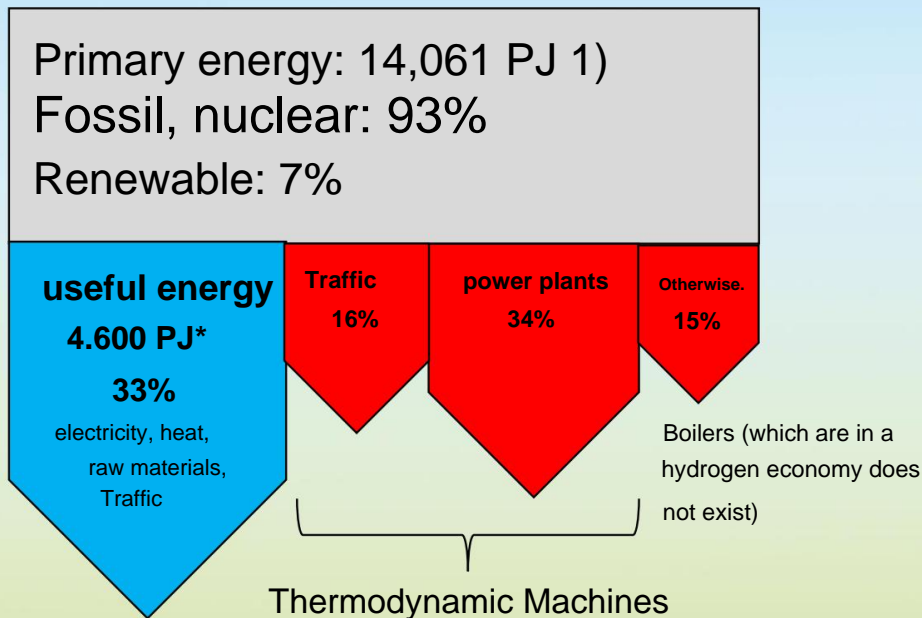


Due to the high efficiency arises at the Hydrogen factory virtually no waste heat

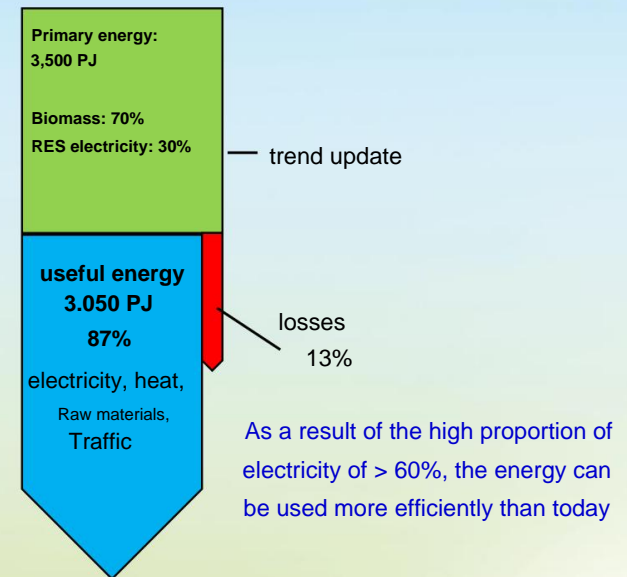


Energy industry today and tomorrow

Energy industry DE 2007



Hydrogen economy DE 2030



no restriction in energy comfort

In a future hydrogen economy, primary energy consumption will drop to a quarter - with the same level of comfort.

1) including approx. 1,000 PJ non-energy consumption
* from BWK61,6(2009) with correction: Electricity=useful energy (4,400+200=4,600 PJ)



Vier factor

An increase in efficiency by a factor of 4 means:

• Energy costs are reduced by at least a quarter

– In addition, costs are reduced because:

- Biomass is cheaper than nuclear and fossil energies,
- the technologies for energy conversion are cheaper,
- the power grid is no longer required,
- no social costs are incurred for energy production.

• The potential of biomass increases by a factor of 4 compared to conventional use



biomass potential

A plausibility analysis

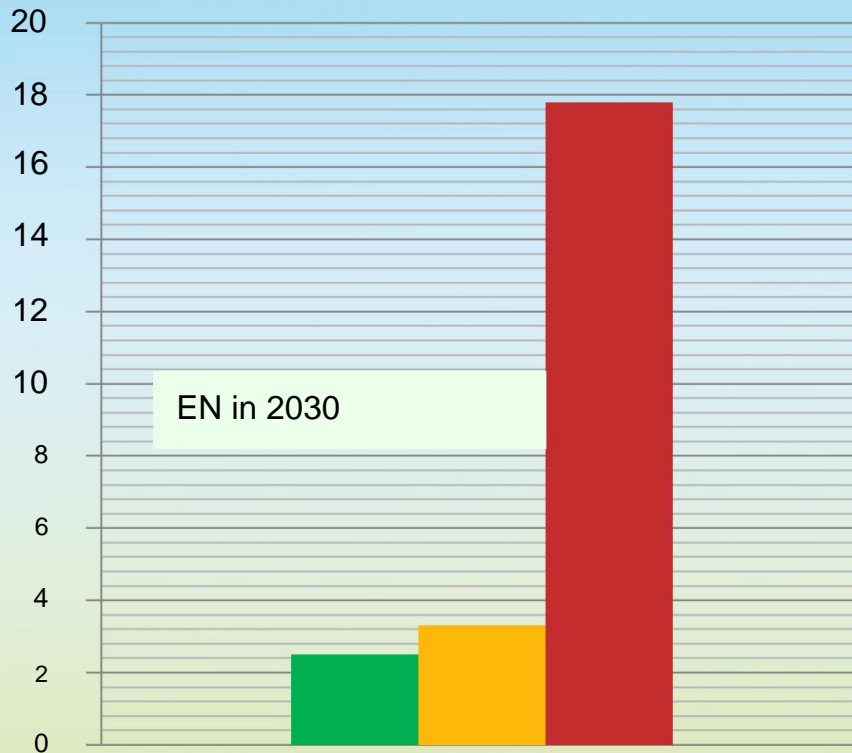
Experts largely agree that biomass can make a contribution of around 20% in our current structures. That's $14,000 \times 0.2 = 2,800$ PJ.

A bio-based hydrogen economy requires around 2,500 PJ of biomass (70% of 3,500 PJ) to replace all nuclear and fossil energies .

That is enough to decouple the bio-based hydrogen economy from oil prices



The organic potential is higher than the need



- Need to replace all nuclear and fossil energies
- Potential of residues and cover crops
- Real Potential *

* If the EU export subsidies for food are stopped, large areas will be freed up for the cultivation of energy crops.

It's enough for tank and plate!



Business as usual?

Our foods can be easily weighed in oil.



About 40% of energy costs are included in everything we buy today.

The use of biomass in the actually existing energy industry means that we will neither have enough energy nor enough food (or will not be able to pay for it) with rising energy prices. It is not in our power to avert this.

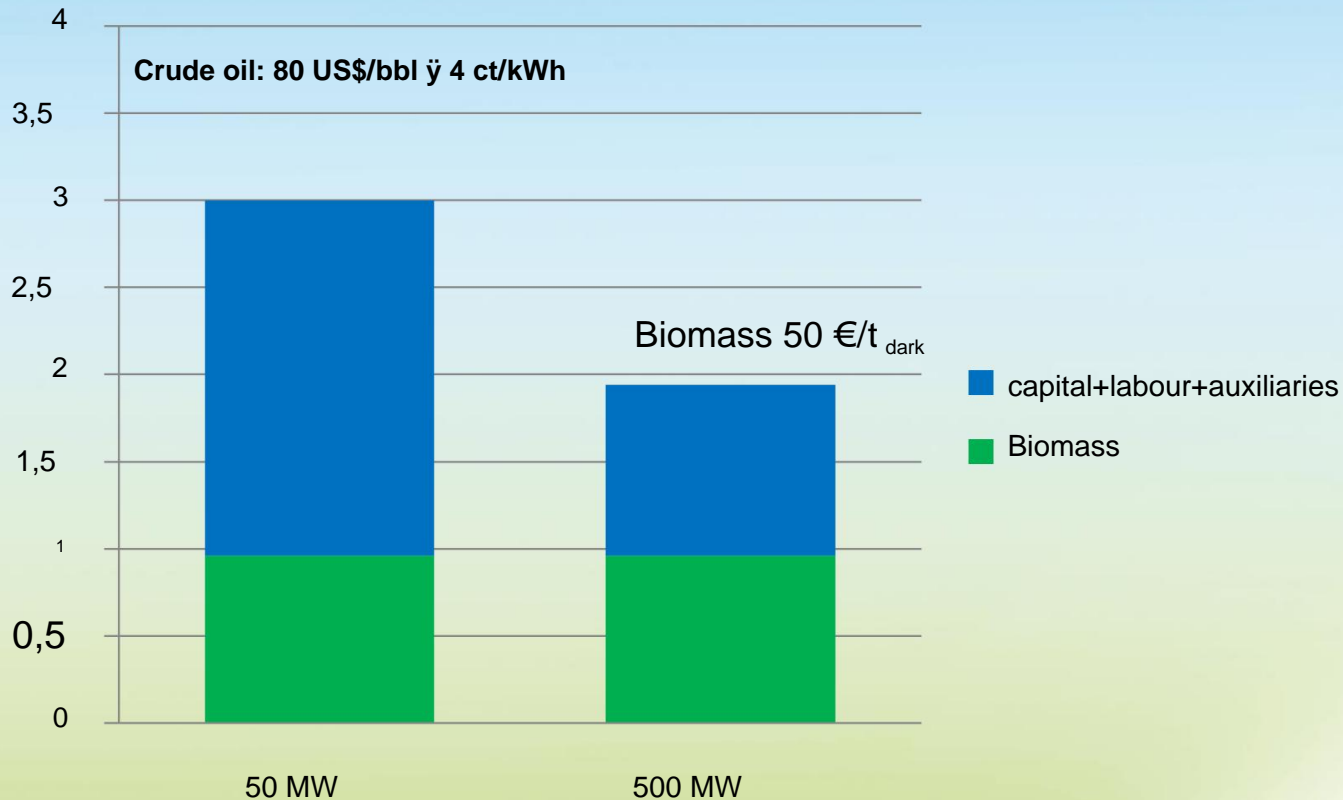
tank and plate!

An overpotential of biomass in a bio -based hydrogen economy makes it possible to decouple food and energy prices from oil prices!

That should be motivation enough.



Bio-hydrogen is cheaper than mineral oil and natural gas



The **household tariffs** are 0.7 ct/kWh higher than the production price.

Electricity or heat then costs **2.7-3.7 ct/kWh**.

With a 50 MW factory, 22,000 (standard) households can be fully supplied with electricity and heat.



From an economic point of view

- Thanks to the added value in the country, Germany can Reduce energy transfers abroad by around €100 billion/a.
- Energy costs can be reduced by around 100 billion €/a.
- The social costs of energy production (external Energy costs) can be reduced by around 100 billion €/a.
- The payment obligations of around €100 billion (debts) through commitments under the EEG can be reduced.

All this will set off fireworks of prosperity!



in Umbaukost

The installation of a sustainable hydrogen economy costs around €40 billion for *Germany* . The energy industry now invests this amount *every year*.

So it only costs us an intellectual effort to free ourselves from dependence on fossil fuels.



Windmills learn to fly

If a hydrogen network is underpinned by a power grid with a high proportion of fluctuating feed-in, no power storage devices are required.

A. Brabeck, spokesman for RWE (2010):

"When the storage problem is solved, renewable energies will fly!"



Network stability through parallel operation with a hydrogen network

Instability due to user behavior and fluctuating

feeds

Power grid stabilized



performance fluctuations



End users with fuel cells feed electricity into the grid or draw electricity from the grid for immediate consumption.



hydrogen network

also mixtures of hydrogen and natural gas

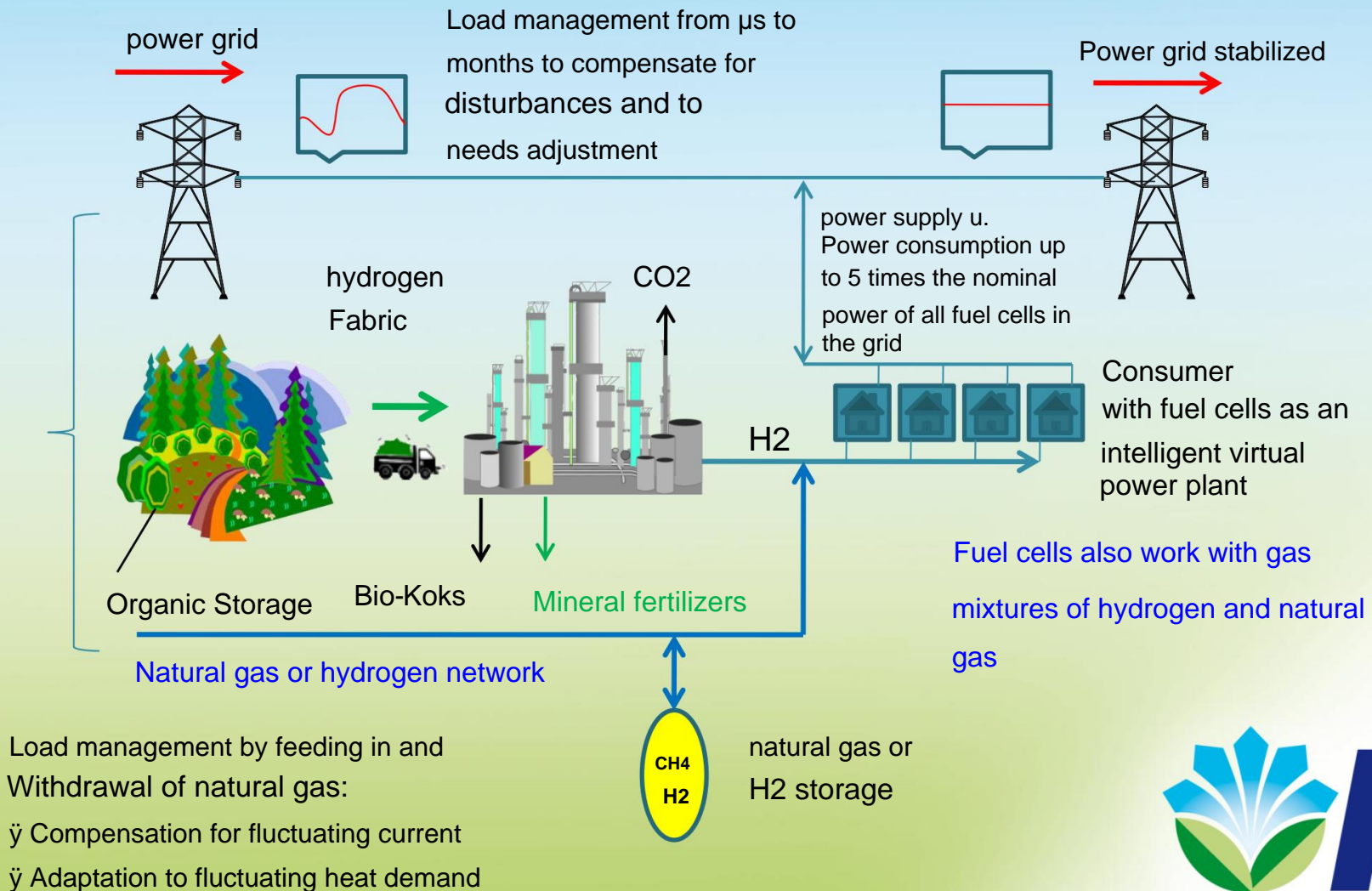
Slight pressure fluctuations



cavern storage



Loss-free power management with bio-hydrogen



"Electricity storage" with bio-hydrogen is a new idea



Energy management from a single source

1. One energy source for everything

1. Biomass

2. One primary energy converter for everything

1. The steam reformer for the production of hydrogen

3. One energy source for everything

1. Storable hydrogen for electricity, heat, fuel and raw materials

4. One infrastructure for everything

1. The former natural gas network transports electricity, heat, fuel and raw materials

5. A secondary energy converter for all

1. The fuel cell for electricity, heat and fuel

6. A raw material for chemical products

1. Hydrogen and the by-product CO₂ make chemistry green

This concept supplies energy "just in time" and can easily absorb fluctuating energies: without losses and without additional costs.



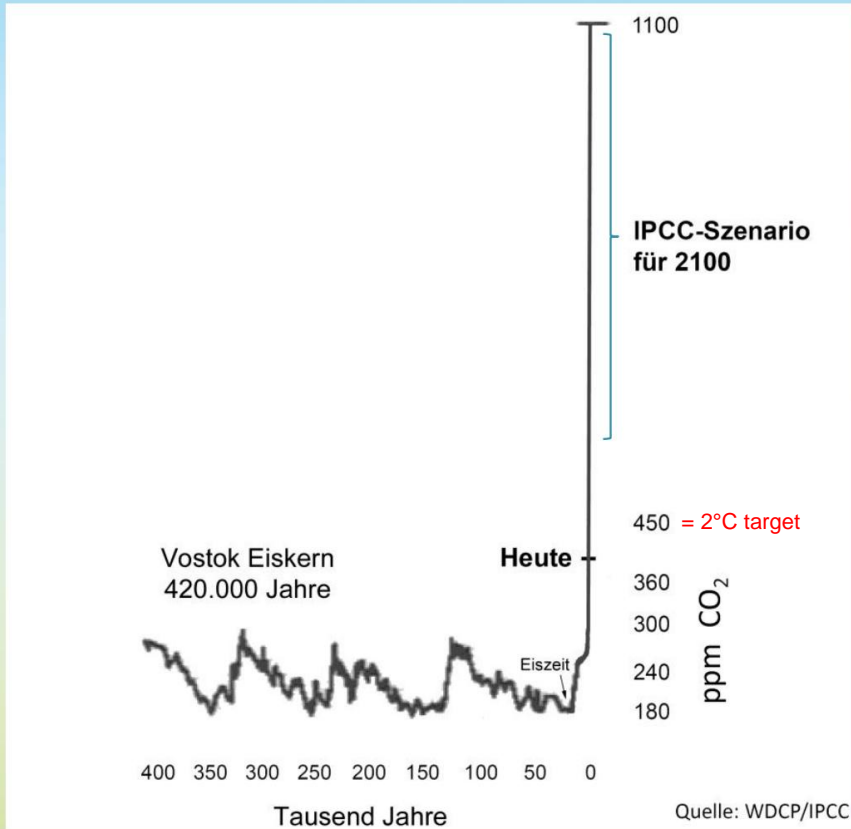
A modern energy industry needs

- No smart European “super grid”
- No “smart meters”
- No networked control for wind, PV, biogas, ...
- No shadow power plants
- No electricity storage (batteries, flywheels, ...)
- No electricity-to-methane concept
- No heat networks
- No energy from nuclear, oil, gas, coal
- No climate protection negotiations

What is needed is not a repair kit for the old energy economy, but an energy concept that is compatible with renewable energies and whose installation only requires an intellectual effort from us. We even get money out of it!



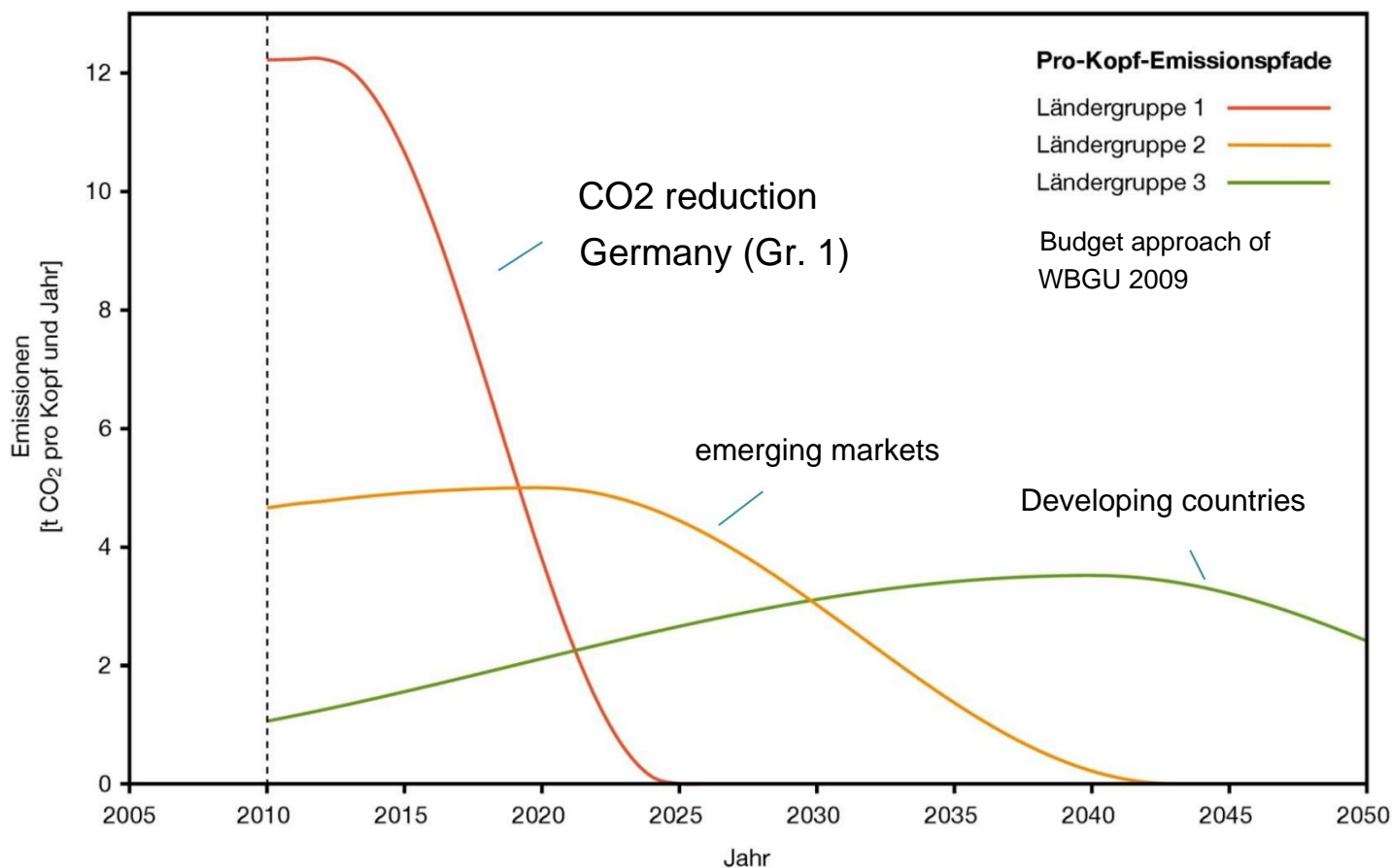
The climate trap



I'm
so fine

All living things react to long-term changes by extinction of the species.

What does the 2°C target mean?



Even the lofty 2°C target means flooding

Gorleben and the downfall of most world cities:

Of the
Sea level will be about 1000 years around
Climb 40-50m.
(Schellenhuber 2010)

Actual government action does not indicate that CO2 emissions could be reduced to zero by 2025.

climate protection negotiations?



According to prevailing opinion, climate and environmental protection cost extra.

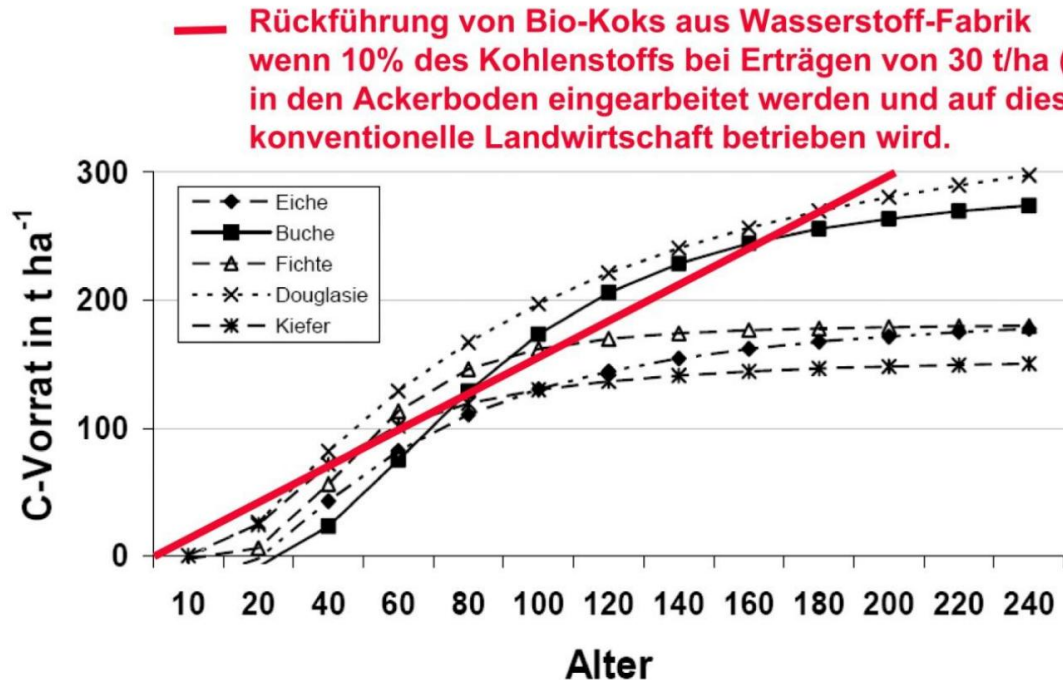
That is why there are global negotiations on burden sharing, in which everyone ensures that the competitiveness of their own location is not endangered.

Why do we still need climate protection negotiations if we implement a concept in which energy is cheaper than today, is produced sustainably and environmental and climate protection does not cause any extra costs?



Reverse the greenhouse effect with Terra Preta

C-Speicherung nach Baumarten



If CO₂ is stored underground,
the red one is
Line 10 times steeper

(nach Schöne & Schulte 1999, verändert nach Kriebitzsch 2005)

Karl-Heinz Tetzlaff 23.06.2009

Wiebke Saathoff

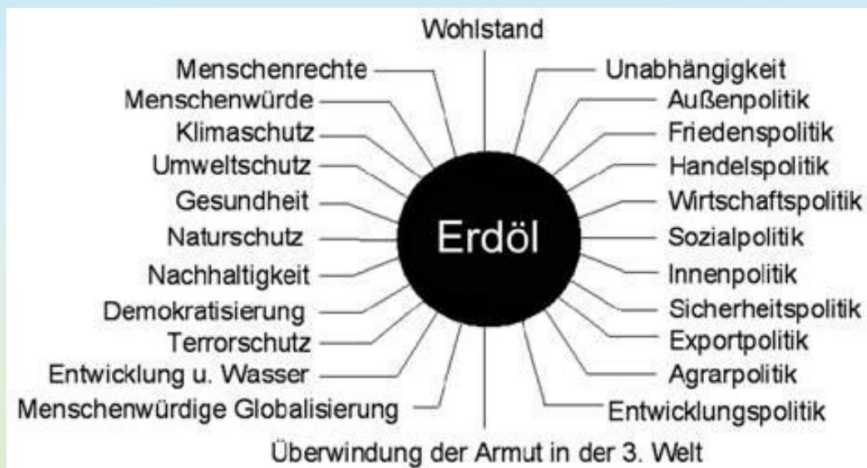
01.04.2008 Bonn

If you don't completely convert the carbon in the biomass into hydrogen, you can reverse the greenhouse effect and make the field more fertile.

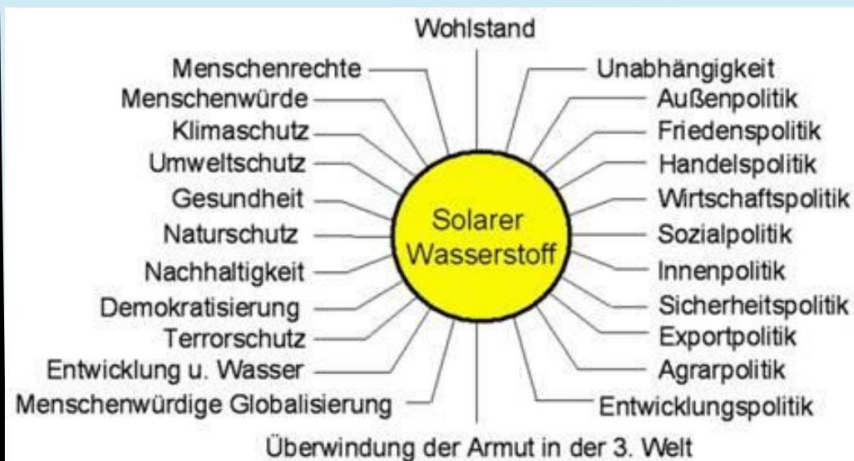


The energy issue is a matter of survival

The black hole



A world at peace

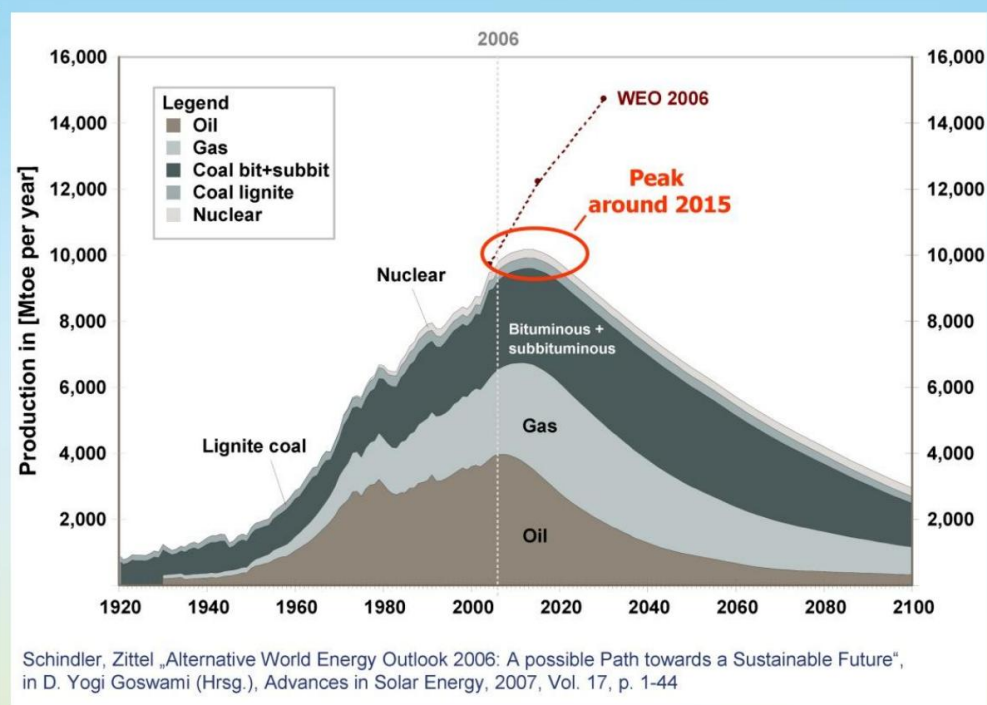
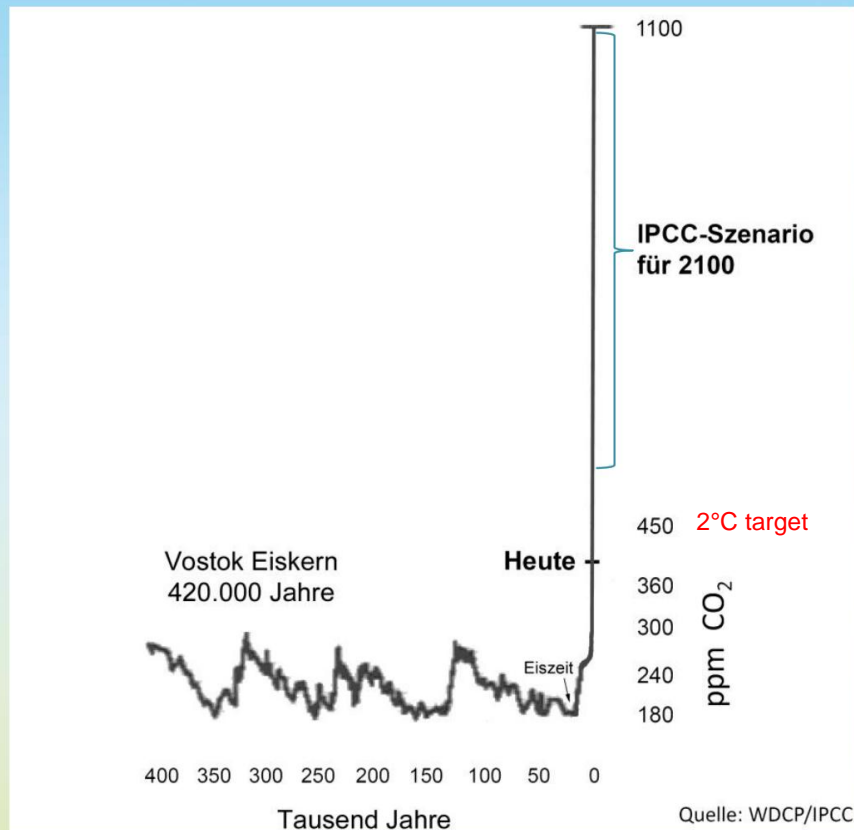


The energy question is the nerve of all things and the existential question of mankind par excellence.

For the purpose of energy procurement, all rules are suspended and all contracts are broken: national, global, economic, cultural, ethical

The introduction of a regional sustainable energy economy will trigger a wave of prosperity. It paves the way to peace, justice and integrity of creation.

The clock is ticking



The prices for fossil fuels and biomass will increase dramatically. On the other hand, if the switch to the green hydrogen economy is made in good time, energy prices will remain stable.

We have a time window of 10-20 years for a quantitative switch to renewable energies. After that we will have no more money to do this.

Rapidly rising energy prices lead to a system crisis!



town hydrogen



A sustainable energy supply must also be able to supply large cities with electricity, heat and fuel .

A green hydrogen economy can do that. It is emission-free, sustainable, economical and more efficient than today's energy supply.

Today's natural gas network already offers the necessary infrastructure



**Thank you for
your
attention**

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