



Potential of Bio-Hydrogen and Constraints of its Utilisation

The Use of Bio-Hydrogen is a
Route to Prosperity, Peace, Clean
Environment and Independence

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The Aim of the Lecture

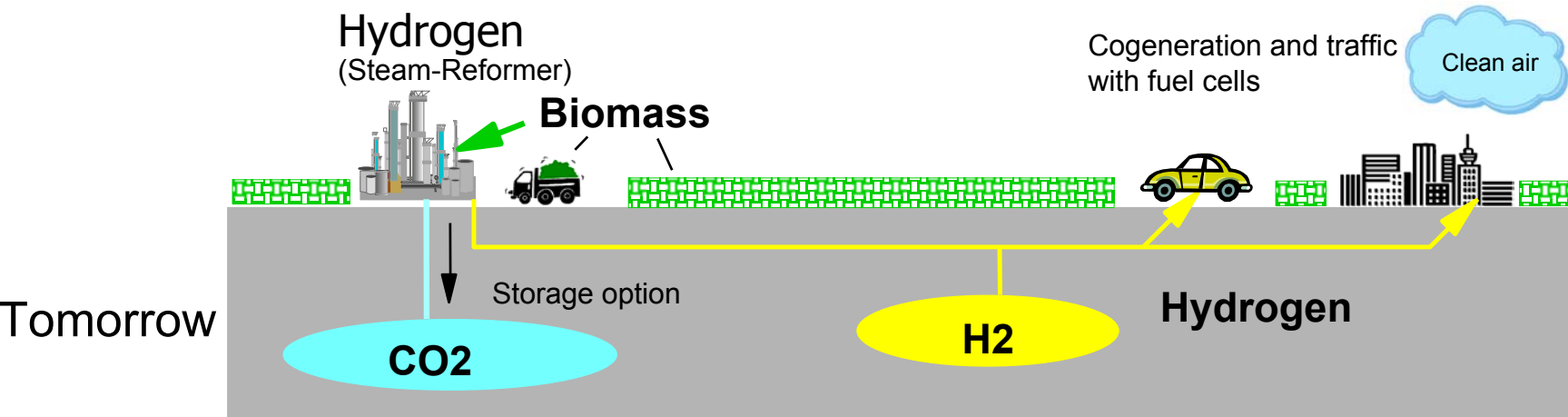
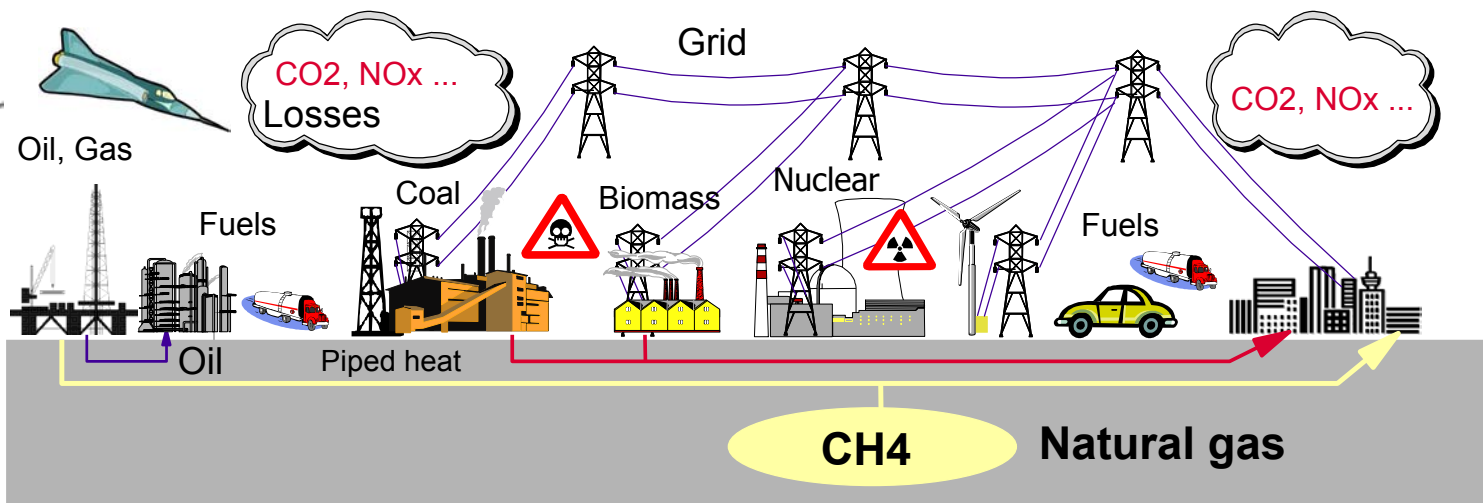
Description of a hydrogen economy in an infrastructure with more than 1 million people.

We have to answer the question: Is a hydrogen economy with biomass a good future for us?

I won't explain in detail how to start.



Infrastructure Today and Tomorrow





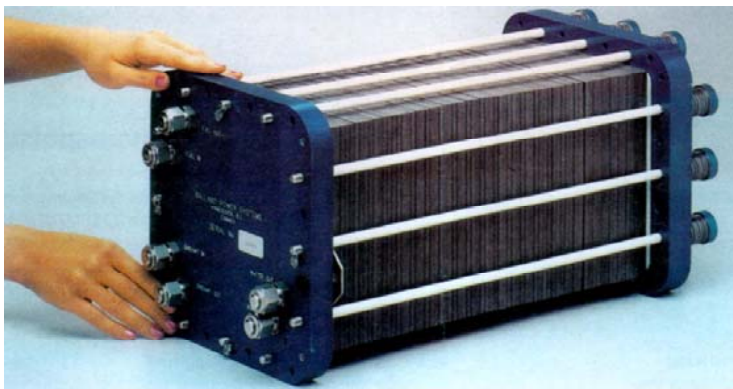
No longer needed



Old Infrastructure cannot compete with power made from bio-hydrogen



Fuel Cell



50 kW

Mass production will bring the costs down to 10 €/kW

Today, hand made fuel cells have specific cost of 500 – 5,000 €/kW.

Requirements:	Cars	50 €/kW
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	Residential	1,000 €/kW
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Mass production has not yet started.

1 Euro = 1.2 US \$



Fuel Cell Types

In a hydrogen economy fuel cells are used primarily for the production of heat not electrical energy. Surplus electrical energy will be converted to heat *. The type of fuel cell is dependent on the desired temperature:

200 °C: membrane fuel cells (PEMFC)

600 °C: molten carbonate fuel cells (MCFC)

900 °C: solid oxide fuel cells (SOFC)

* With this priority one gets a heat guided energy economy without energy losses, because there is more electricity at all places than need

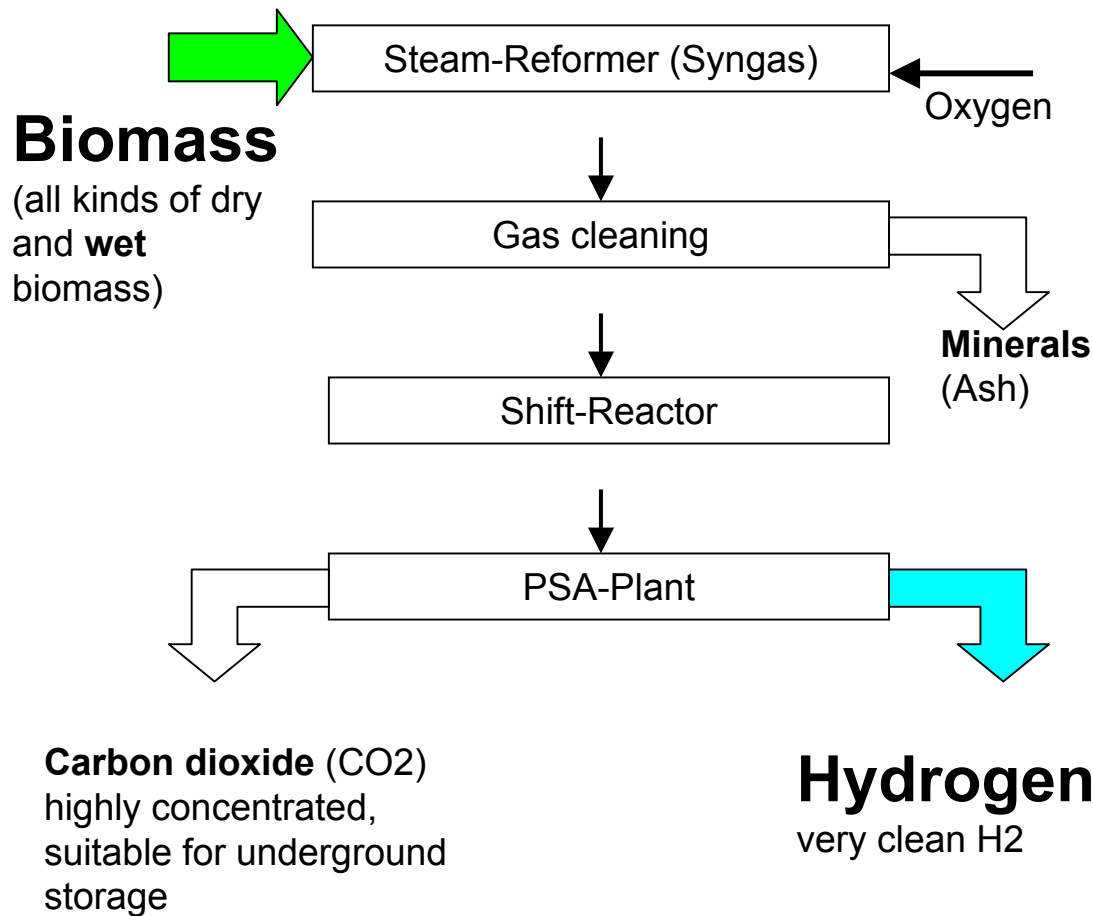


Reliability of Fuel Cells

- Successful in the laboratory environment
- More tests needed by the customer



Hydrogen from Biomass



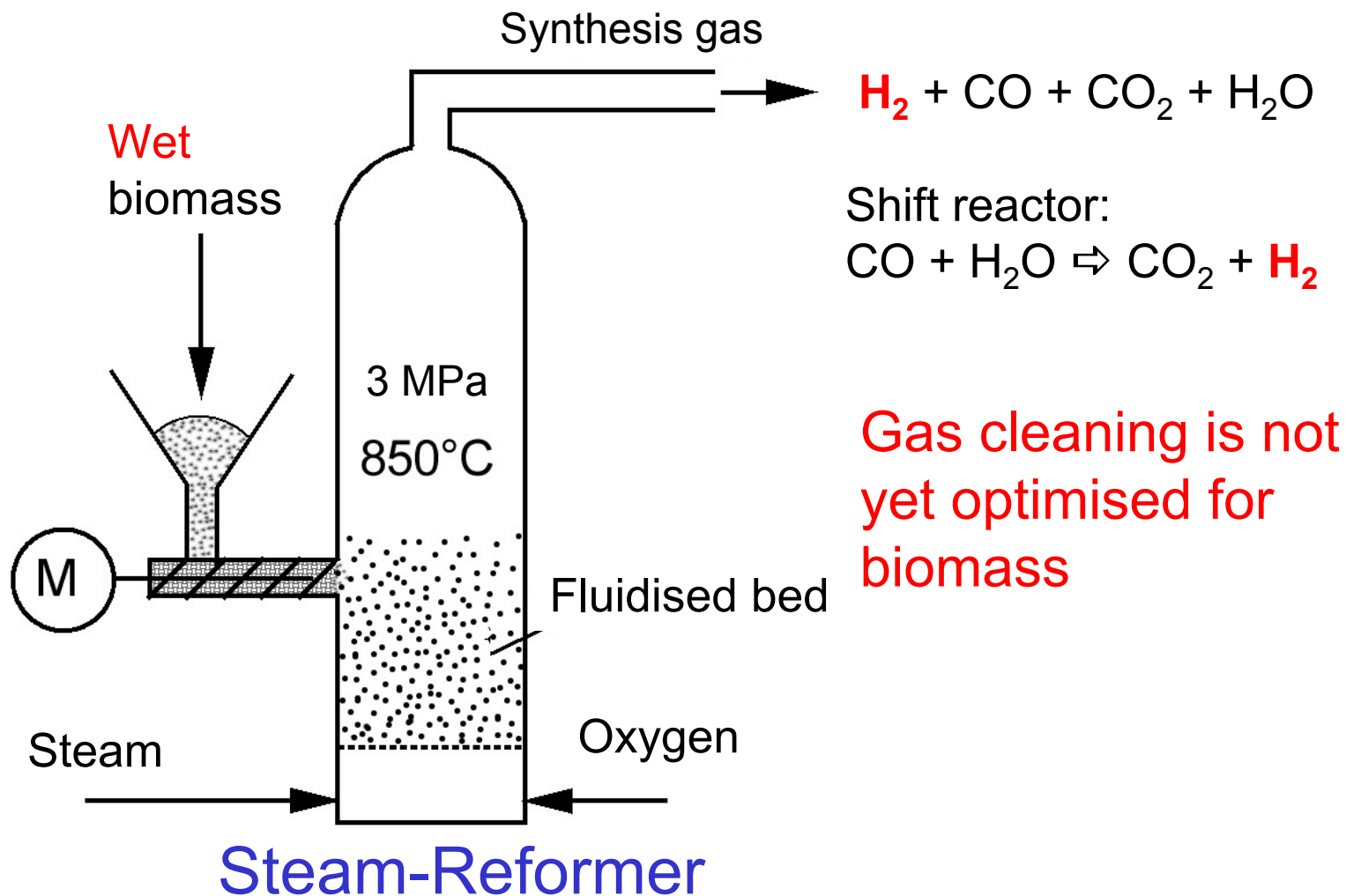
← This part needs to be optimised for biomass

No air pollutants
(no chimney)

Industrial nations have more than 150 years experience in gasification



Hydrogen Production by Industrial Fluidised Bed Reactor





Production of Synthesis Gas



Syngas is converted to electrical energy by internal combustion engine (ICE)

Steam-Reformer in Austria 8 MW_{th}



Efficiency, Residential

Farming

Biomass

100% (LHV)*

Central conversion

Hydrogen
Steam-Reforming

78% (LHV), 92% (HHV)

Pipeline transport

Decentralised use

Fuel Cell
E = 60%

90,5% heat and power

**We get a heat guided
energy economy
without heat losses**

Hydrogen

1 kWh (LHV)

fuel cell

**0.6 kWh
electrical**

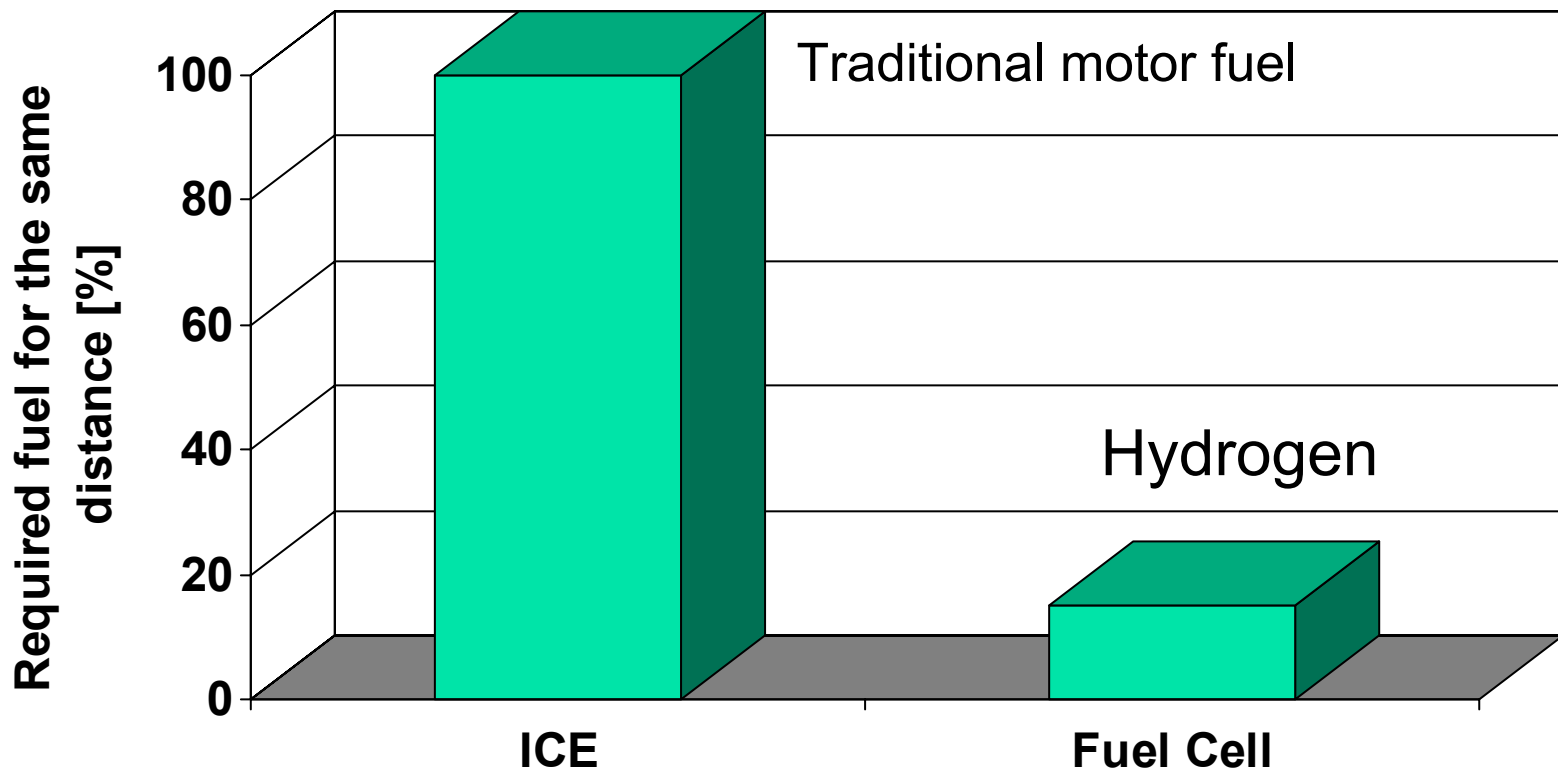
**0.56 kWh
heat**

Useable energy = 1.16 kW

* Lower Heating Value



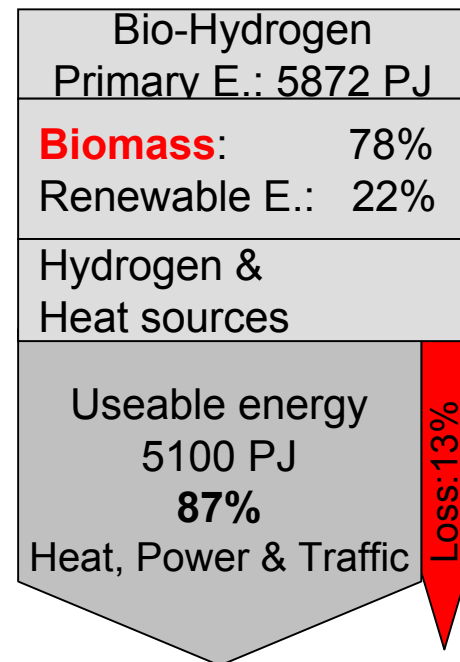
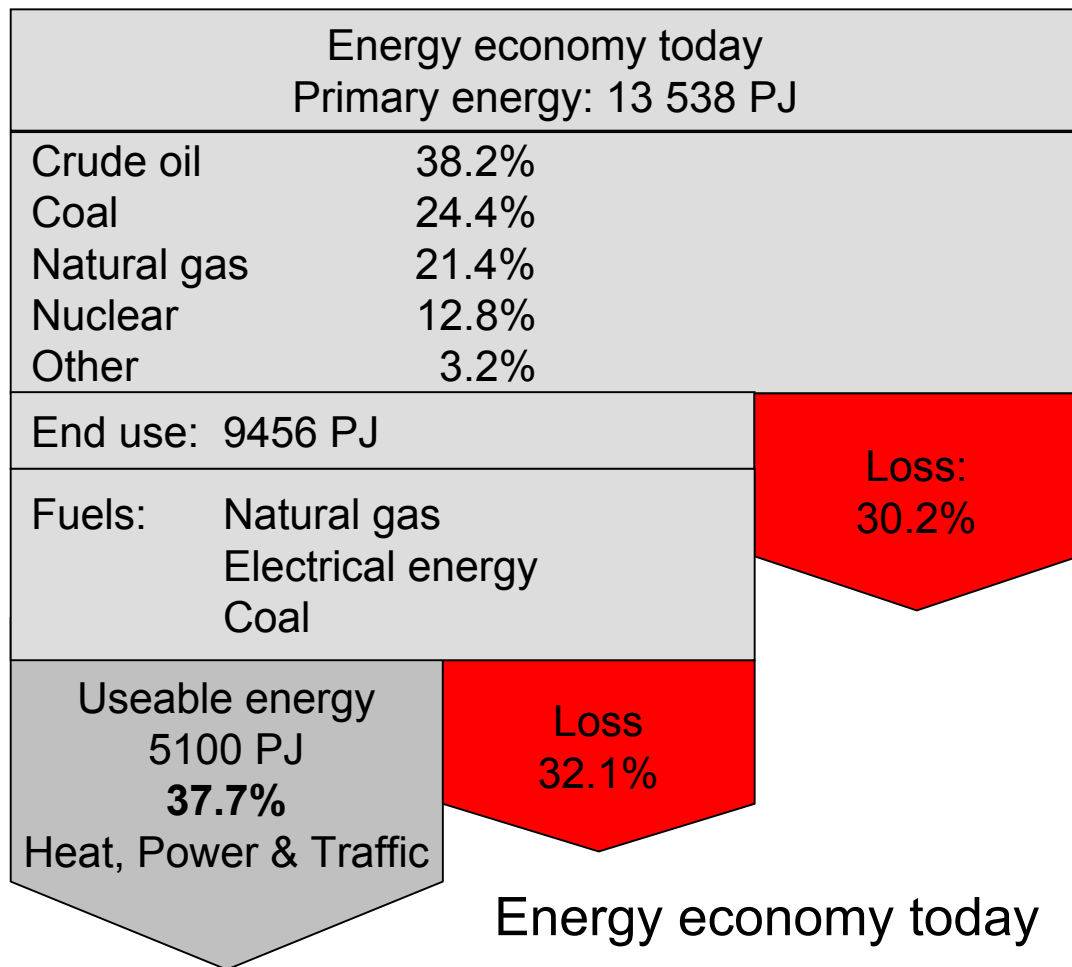
Efficiency, Traffic



Hydrogen costs: 0.40 €/ 100 km (Germany)



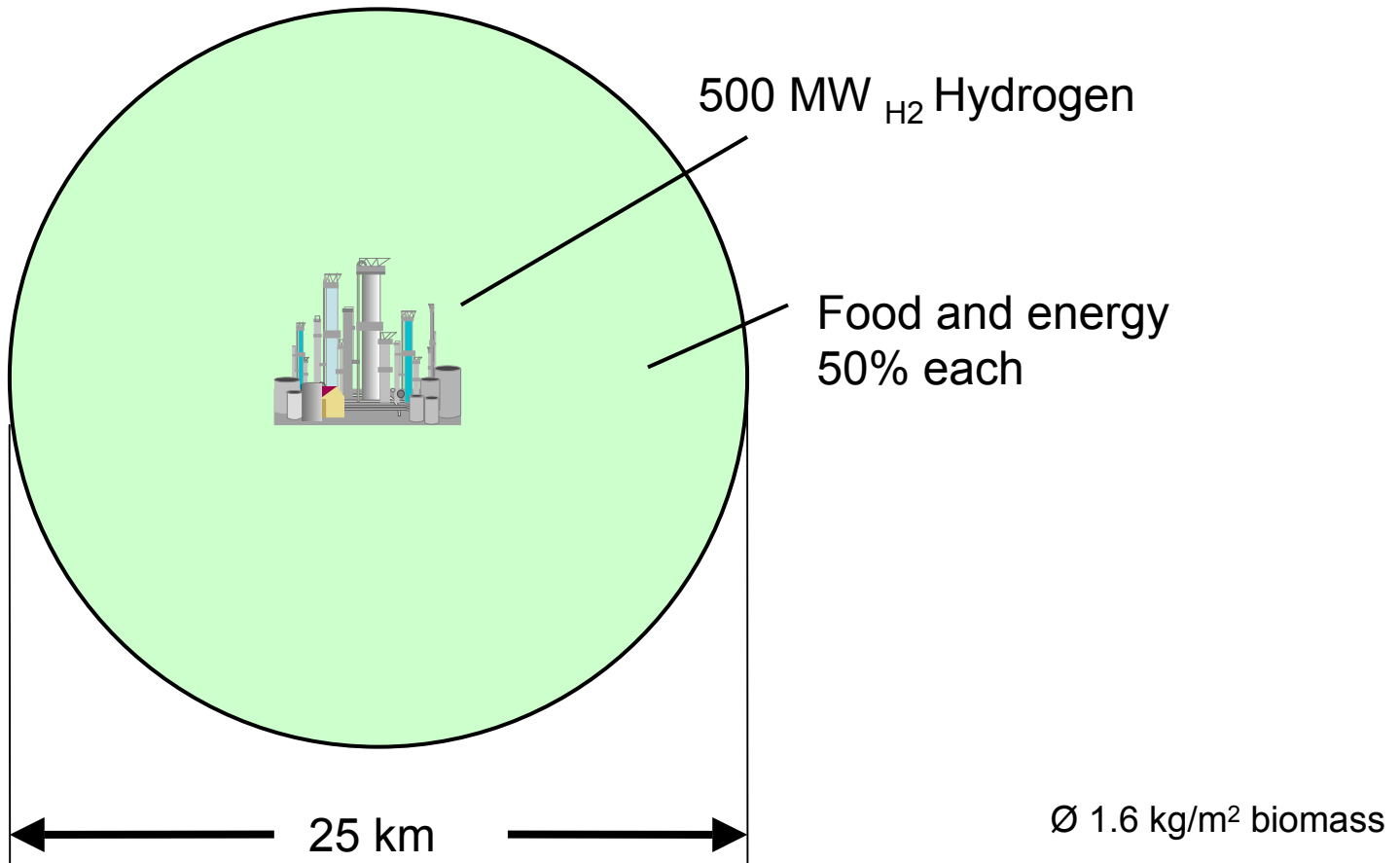
Energy-Efficiency, Germany



The energy costs are halved also, for poor countries even more

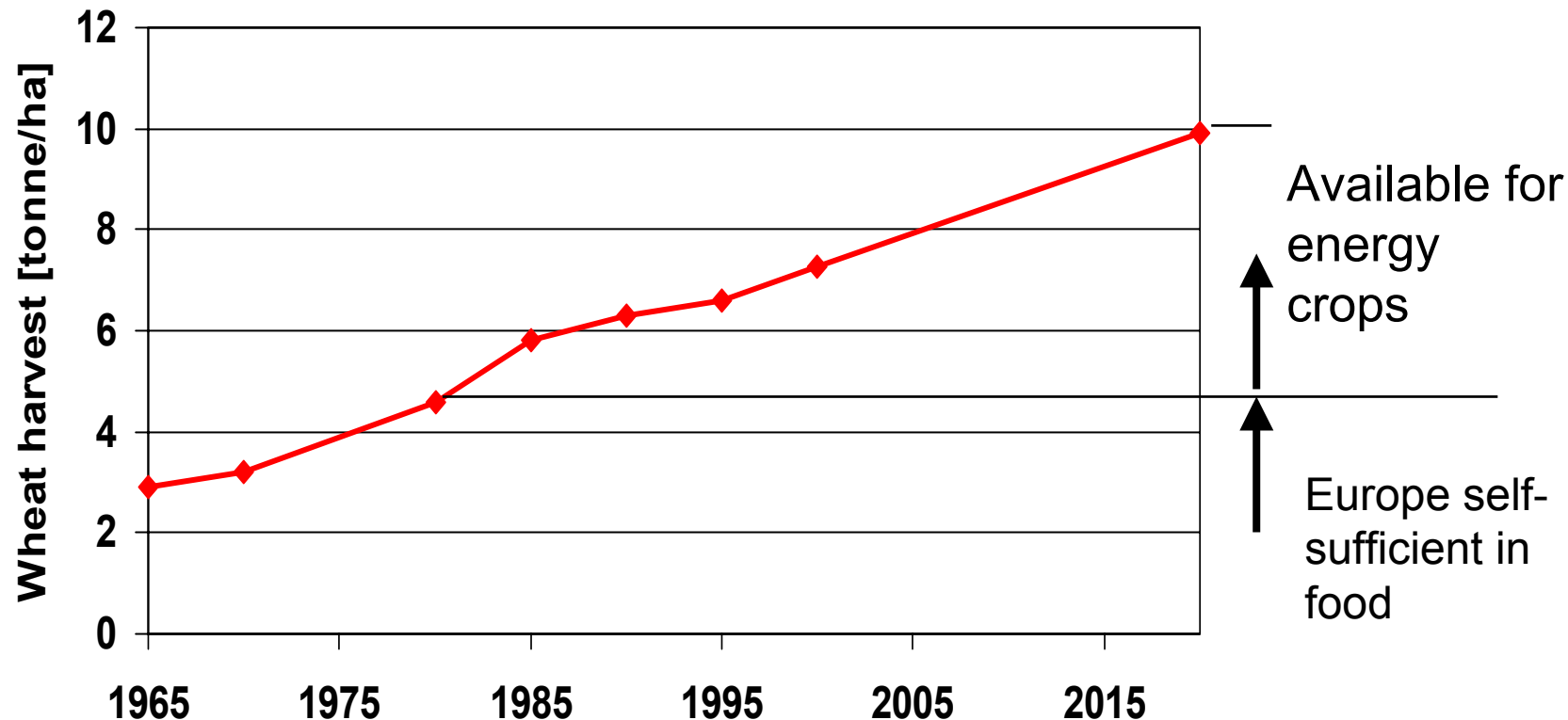


Professional Scaled Hydrogen Plant





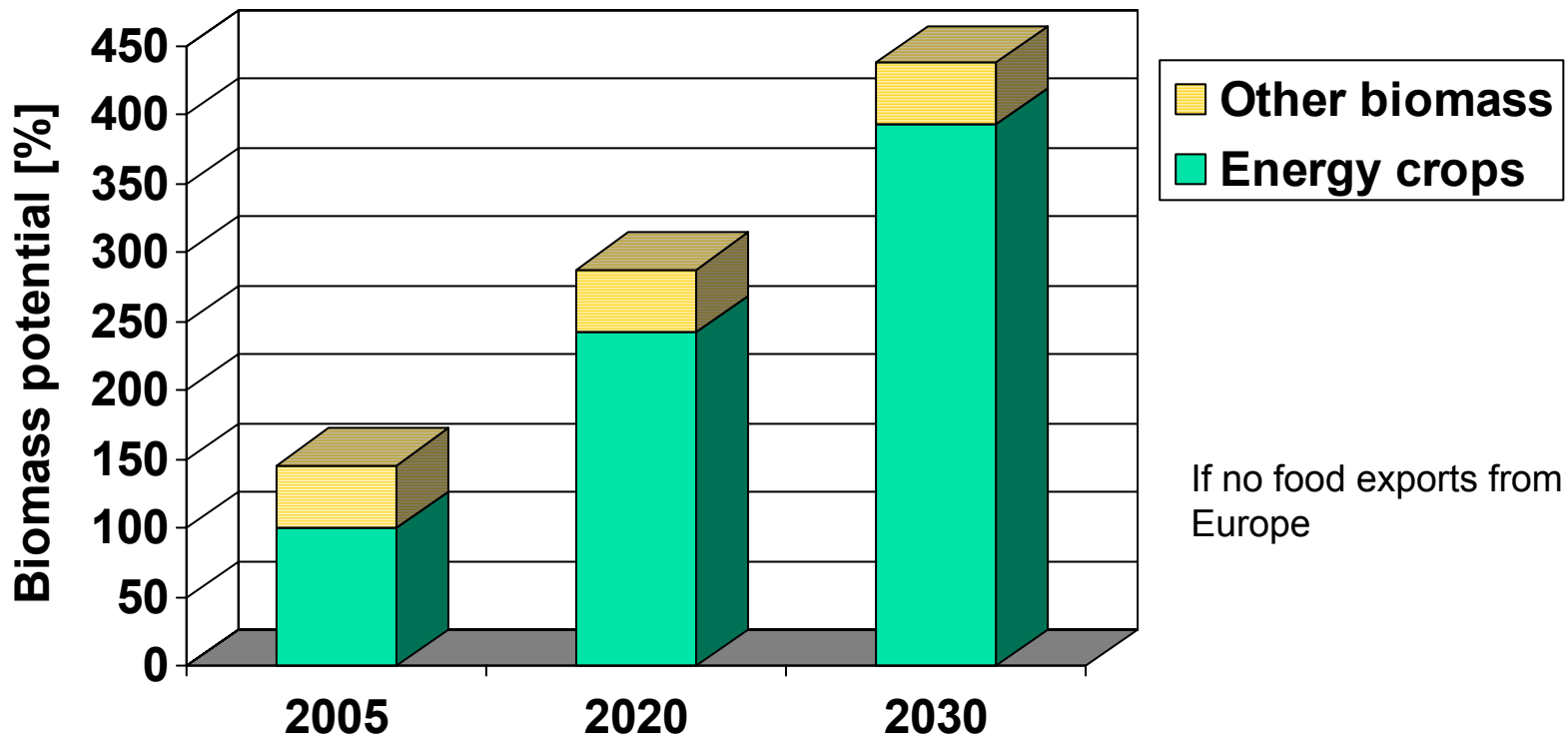
Space for Energy Plants, EU





Biomass Potential Europe

The european energy requirement won't increase



- The rich countries need neither fossil energies nor atomic energy.
- Lower exports of agricultural products at higher prices



Potential of Bio-Energy in Developing Countries

Most developing countries can satisfy their energy requirements almost completely with waste biomass, if they use the more efficient hydrogen technologies.

Needed are:

- Awareness (dry **and** wet biomass)
- Education of farmers and engineers
- Investment

A promising strategy is not food **or** energy but food **and** energy.



Hydropower versus Hydrogenpower



Turbines
versus Bio-
Hydrogen
and Fuel
Cells



Hydropower: 0.1 GW

Hydropower: 0.01 GW

Fuel Cell Power: 1-10 GW

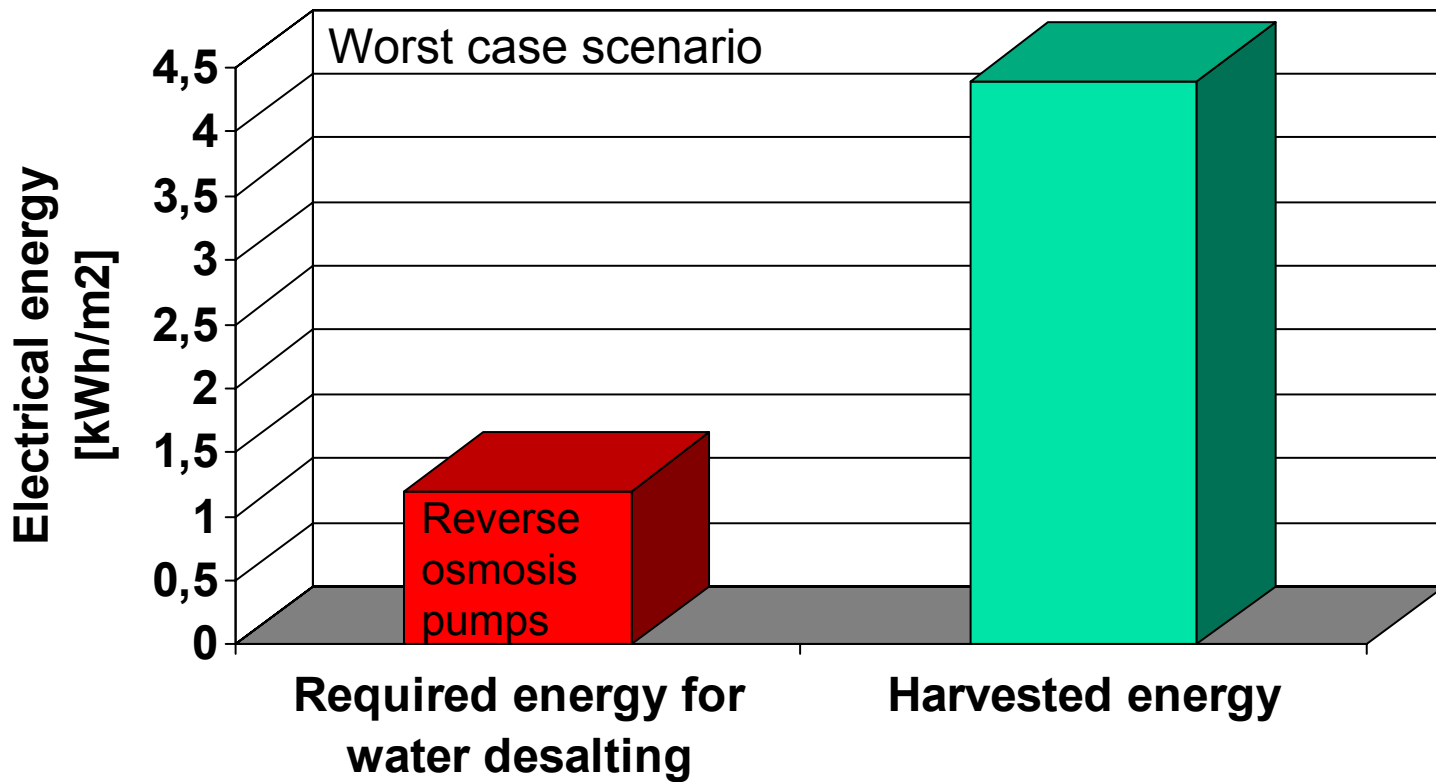
Fuel Cell Heat: 1-10 GW

Food: more than enough

Using water for growing biomass to make hydrogen is 10 to 100 times more effective than hydropower



Desalted Ocean Water for Energy Production



With artificial irrigation, people in former desert areas can live with the same standards of diet and energy as people in Europe

Irrigation water: 0,3 m/y (corresponds to 0,75 m/y additional rain); hight 700 m over ocean; harvest 2kg/m² (20t/ha). Please notice: water is not more expensive than water from most big dam reservoirs



Green desert





Water = Energy = Water

If you have water you can produce bio-energy.

If you have bio-energy you can produce much more water.

If you have water



Bio-Hydrogen: a magic formula



The Future Energy is Water

In the long term:

- More efficient use of water
- Bringing desalted ocean water to arid areas (making the rivers go backwards)



Cost of Hydrogen

European farmer gets 73 €/tonne

73 €/tonne = 0.015 €/kWh is equivalent to US \$ 30/bbl crude oil. The European farmer can live well on that without subsidies.

Natural gas for households was more expensive than bio-hydrogen in Germany (2004).

If a Chinese farmer gets 20 €/tonne

Waste biomass or as an example for low income countries

Figures: Lower Heating Value (LHV) before tax

1 Euro = 10 RMB = 1.2 US \$

Production costs for hydrogen, Europe

Payment to the farmer	0.015 €/kWh
Loss	0.005 €/kWh
Investment	0.005 €/kWh
Σ	0.025 €/kWh
Industry rate	0.028 €/kWh
Household rate*	0.032 €/kWh

Production costs for hydrogen, China

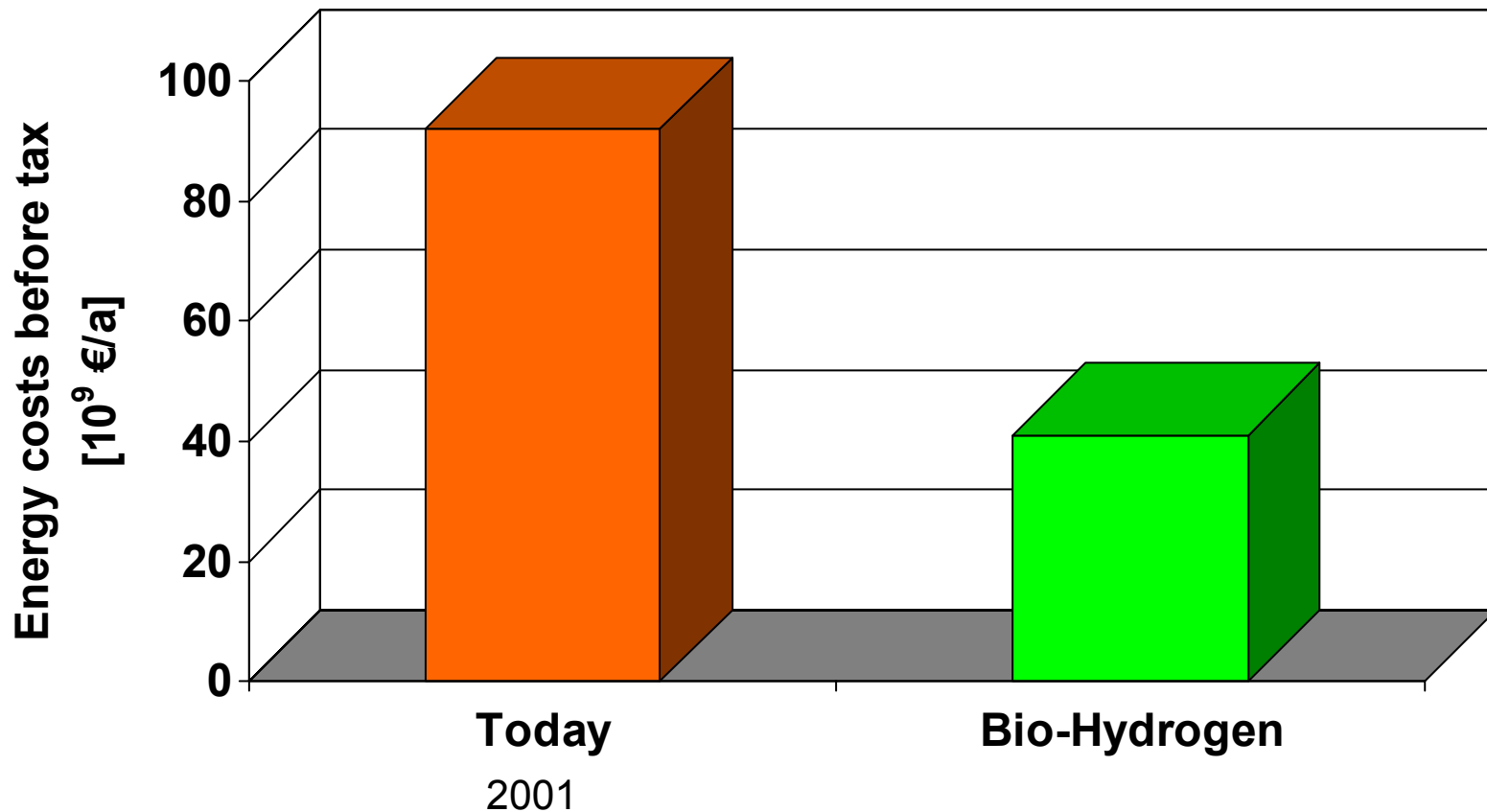
Payment to the farmer	0.0041 €/kWh
Loss	0.0012 €/kWh
Investment	0.003 €/kWh
Σ	0.0083 €/kWh
Industry rate	0.010 €/kWh
Household rate*	0.011 €/kWh

* Price of electrical energy at home



Energy costs in Germany

Germany is the worst case in the world



Lower costs through higher efficiency and simpler infrastructure



Why does nobody start with a bio-hydrogen economy?

- Nobody knows the benefits
- Energy companies are not amused
- There is a big „chicken & egg“ problem
- The world only looks for electrical energy
- Due to subsidies for electrical energy, every attempt at the use of hydrogen is nipped in the bud.



How to start?

**There are many possibilities.
Here two remarks:**

- **Start without fuel cell**
 - Already competitive with oil & gas
 - But more than 100,000 customers necessary
- **Start with state support.**



Happy World

Bio-energy will give the
world prosperity, peace,
clean environment and
independence

Flowers instead of war over oil





Thank You

- For invitation
- For listening

Further informations:

Book: Bio-Wasserstoff
ISBN 3-8334-2616-0

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