Sustainable Hydrogen Economy

A 21st Century Milestone

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H_2 Patent GmbH (Ltd)

Dipl. Ing. Karl-Heinz Tetzlaff

- Technical genius behind the inventions, author of various books about Hydrogen technology
- Longstanding experience in the fields of electroanalysis and fuel cell technology at Höchst AG, Germany (retired)

Dr. Ing. Wolfgang Wendel

- Director Research & Development
- Experience in designing and operating pilot plants in chemical industry, cost estimation both in research and engineering departments

Hayo Sieckmann

- Managing Director H_2 Patent GmbH

Hubertus Rau

- Managing Director H_2 Patent GmbH

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Key Targets

CO_2-neutral and sustainable production of pure hydrogen at low production costs on a non fossil basis

Utilisation of domestic resources (biomass), involving regional agriculture

Distribution via the infrastructure of the existing (natural) gas grid

Conversion of Hydrogen to electric power and heat on site at customers‘ houses and / or factories

Political and economic independence for entire national economies, companies and private consumers

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Key Points

- The technology as patented / licensed by the company H_2 Patent GmbH (Ltd) is based on a well-established production scheme („city gas“). Industrial gasification has been used in industrial nations for 180 years. H_2 Patent offers an adapted, modern and significantly improved method.
- H_2 Patent technology produces a revolutionary and unique tar free synthesis gas – pure hydrogen. It can be used without any restriction whatsoever in fuel cells.
- All processes are CO_2-neutral. A genuine hydrogen economy is absolutely sustainable and the greenhouse effect can even be reversed. *Terra Preta* as a chemical by-product is a fertiliser of the highest quality and even has the ability to turn deserts green.

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$$\text{Biomass} + H_2O \rightarrow H_2 + CO_2$$

300-1000°C

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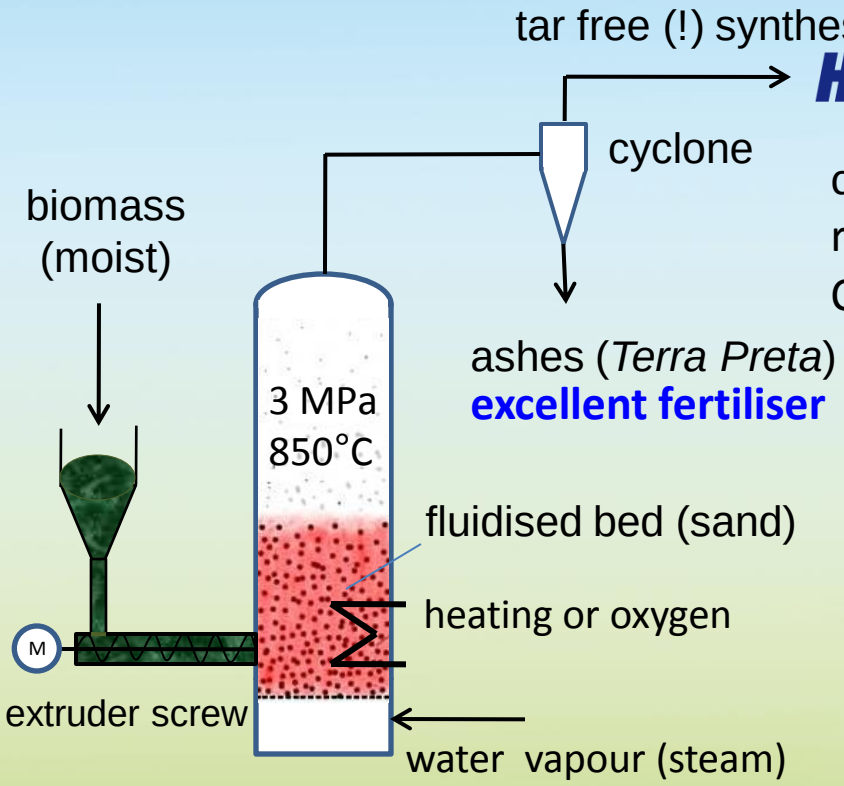
Production of Hydrogen



chemical reaction in the shift-reactor:

CO + H_2O ⇨ CO_2 + H_2

feedback of heat into the process enables an energy efficiency of up to 93 %

Steam-Reformer

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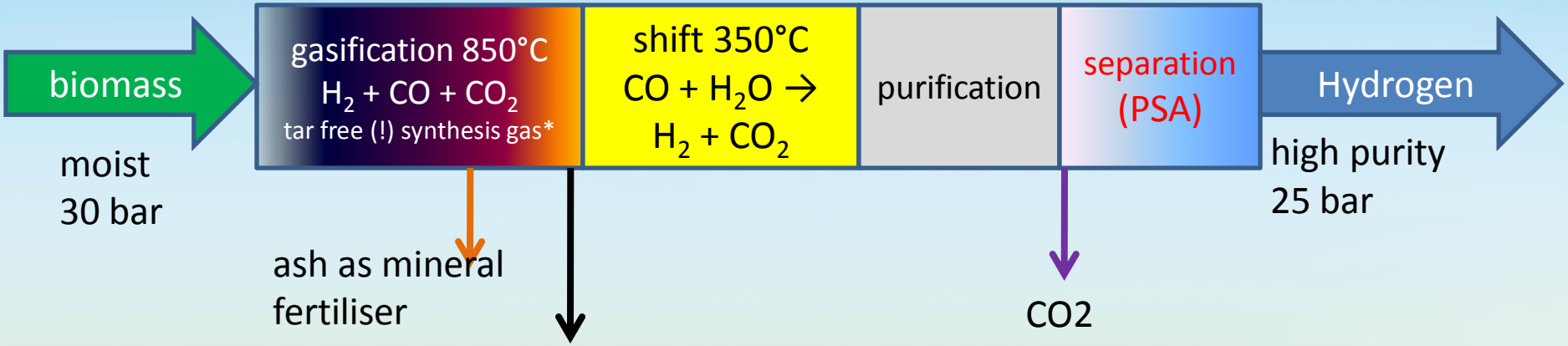
Industrial Production of Hydrogen in Pressurised Cascaded Fluidised Beds – an innovative process



option:
charcoal as soil conditioner (*Terra Preta*)

- ability to turn deserts green (ecological reclamation of land)
- reverses the greenhouse effect

Industrial gasification as such has been practised for 180 years in all industrial nations

* Tar free synthesis gas is a technical breakthrough and one of the most important key point of the H_2 Patent technology. The ability to produce tar free synthesis gas is a pre-condtition for high efficiency.

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- CO_2- neutral
- sustainable
- available
- tailor-made, customised size
- profitable from day one

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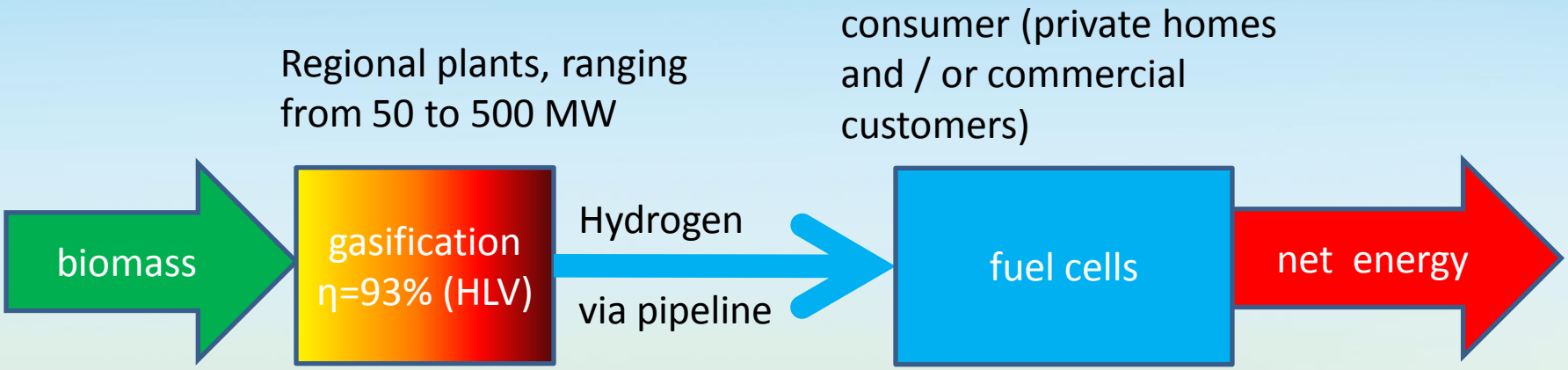
Efficiency of the Energy Chain



- pressurised Hydrogen (25 bar) is transported to the consumer without loss
- there is adequate scientific proof that existing (natural) gas grids can be used for the transport of Hydrogen without any risk, danger or problems
- Hydrogen can also be ‚hooked' onto natural gas (at present about 30 % admixture feasible)

100% to 110% of the lower heating value of biomass, 50 % are available as electric power

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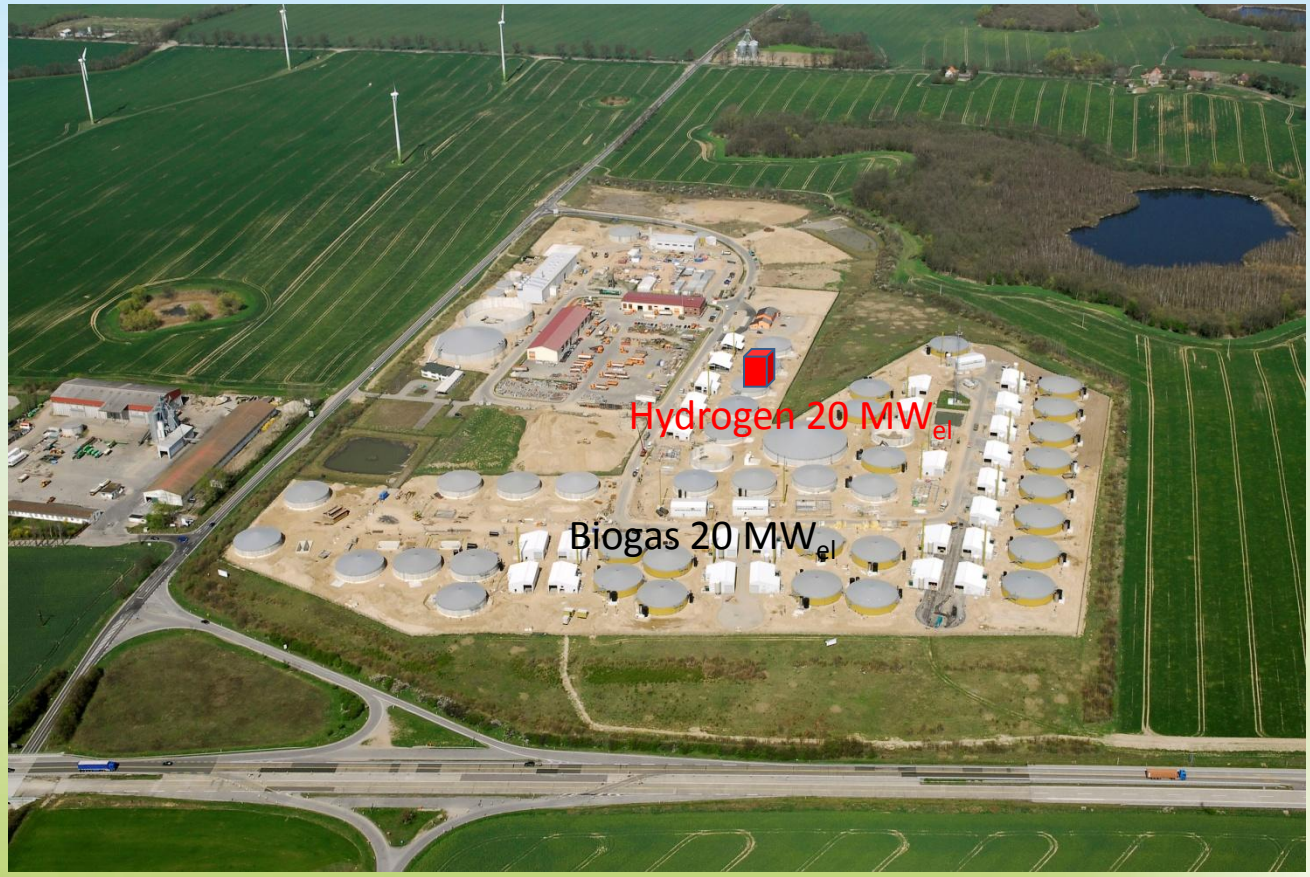
Size of an H_2 plant (20 MW_{el}) in direct comparison with an entire 20 MW_{el} biogas plant



Projection

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Economic Point of View

Production Costs - H_2

50 MW H_2 plant, prices quoted net, no tax*
based on 100 € / t biomass, dry

	[ct/kWh] lower heating value (lhv)	[ct/kWh] higher heating value (hhv)
production costs of H_2 (incl license)	2.3	1.9
industrial tariff (incl 0.3 ct / kWh distribution costs)	2.6	2.2
tariff for private households (incl 0.7 ct / kWh distribution costs)	3.0	**2.5**

500 MW H_2 plant, prices quoted net, no tax*
based on 100 € / t biomass, dry

	[ct/kWh] lower heating value (lhv)	[ct/kWh] higher heating value (hhv)
production costs of H_2 (incl license)	1.5	1.3
industrial tariff (incl 0.3 ct / kWh distribution costs)	1.8	1.5
tariff for private households (incl 0.7 ct / kWh distribution costs)	2.2	**1.9**

* Remuneration of 30 € / ton CO_2 has been calculated for certificates. Without this effect, H_2 would cost about 1 ct / kWh more.

Note please:
All calculations in this presentation are based on certain economic assumptions, ie the production costs and other assumptions relate to the German / European market. The basic economic data might have to be readjusted to accommodate conditions prevailing in other markets.

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Evaluation of Economic Efficiency

50 MW pilot plant : start-up phase (1.5 years)

	2010	2011	20123	...	2022
Total Capital Investment	35,000,000 €				
Owner's equity	10,500,000 €				
Debt capital / external finance	24,500,000 €				
Revenues and Expenditures					
Income					
H_2 revenues*	0 €	12,528,000 €	25,056,000 €		25,056,000 €
Costs					
Depreciation	1,000,000 €	3,500,000 €	3,500,000 €		0
Maintenance and repair	0 €	0 €	1,750,000 €		1,750,000 €
Insurance	700,000 €	700,000 €	700,000 €		700,000 €
Personnel	800,000 €	800,000 €	800,000 €		800,000 €
Electricity	1,000,000 €	2,150,000 €	4,300,000 €		4,300,000 €
Biomass	0 €	3,300,000 €	7,700,000 €		7,700,000 €
Gas distribution	0 €	0 €	0 €		0 €
Interest	612,500 €	1,168,231 €	1,108,623 €		321,396 €
Repayment	567,693 €	1,135,386 €	1,251,763 €		2,038,990 €
Gross proceeds before tax after depreciation	-4,680,193 €	-225,617 €	3,945,614 €		7,445,614 €
Cash flow, cumulated	-3,680,193 €	-405,810 €	7,039,804 €		81,552,713 €
Equity capital commitment	-14,180,193 €	-10,905,810 €	-3,460,196 €		71,052,713 €
IRR over 15 years					86.67 %
EBITA in %	-35.05 %	-2.15 %	37.58%		70.91 %

- *feed-in tariff of 6 € cents / kWh for H_2
- the current market price ranges from 5.5 – 7.5 € cents
- an additional eco-incentive (environment-friendly technology) of 2 € cents/kWh is realistic

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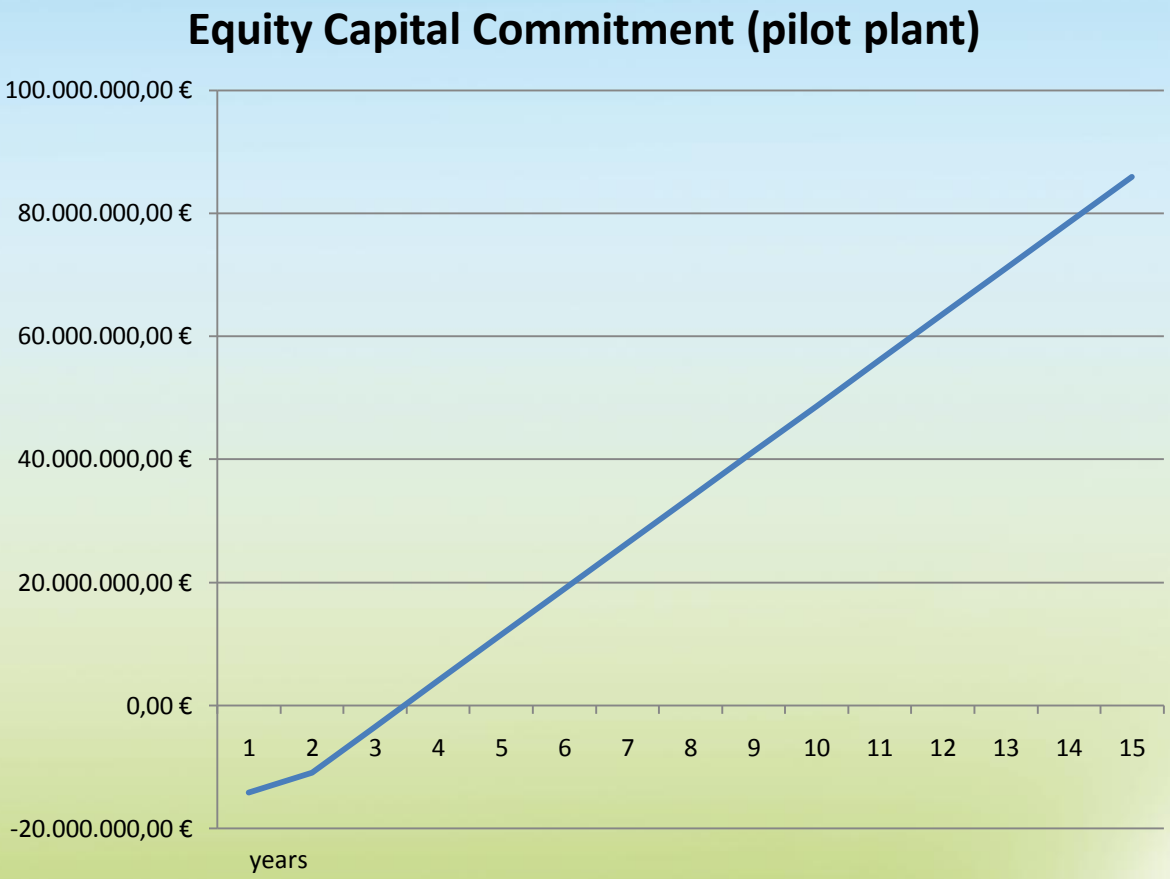
Evaluation of Economic Efficiency

50 MW pilot plant : equity capital commitment



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Evaluation of Economic Efficiency

500 MW plant

	2010	2011	...	2020
Total Capital Investment	80,000,000 €			
Owner's equity	16,000,000 €			
Debt capital / external finance	64,000,000 €			
Revenues and Expenditures				
Income				
H_2 revenues*	250,560,000 €	250,560,000 €		250,560,000 €
Costs				
Depreciation	8,000,000 €	8,000,000 €		0 €
Maintenance and repair	4,000,000 €	4,000,000 €		4,000,000 €
Insurance	1,600,000 €	1,600,000 €		1,600,000 €
Personnel	1,200,000 €	1,200,000 €		1,200,000 €
Electricity	43,000,000 €	43,000,000 €		43,000,000 €
Biomass	77,000,000 €	77,000,000 €		77,000,000 €
Gas distribution	34,000,000 €	34,000,000 €		34,000,000 €
Interest	4,000,000 €	3,814,631 €		1,668,447 €
Repayment	3,707,383 €	3,892,752 €		6,038,936 €
Gross proceeds before tax after depreciation	74,052,617 €	74,052,617 €		82,052,617 €
in % of the owner's equity	462.83 %	462.83 %		512.83 %

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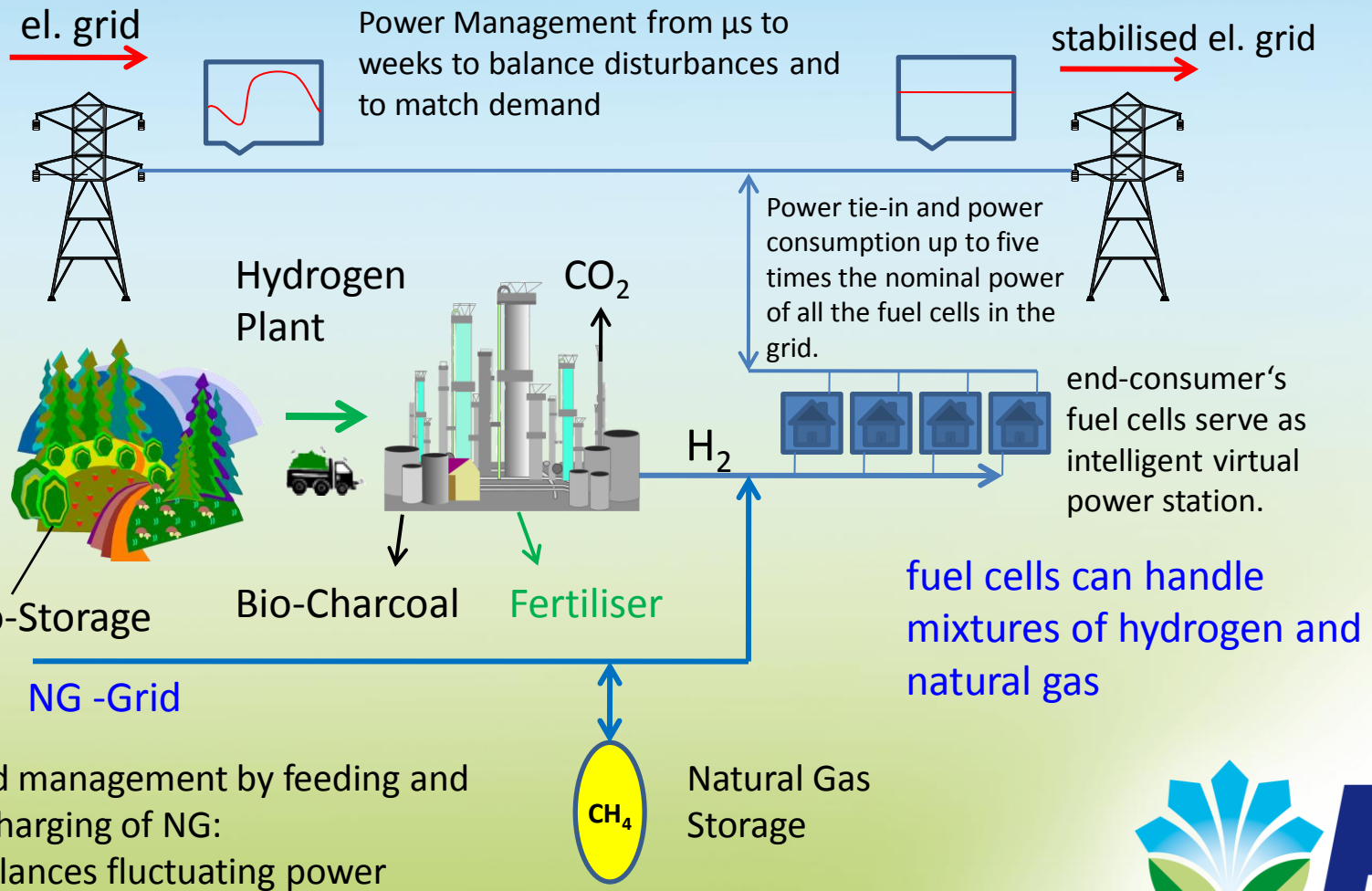
Power Management without energy loss - the Hydrogen solution



fuel cells can handle mixtures of hydrogen and natural gas

Load management by feeding and discharging of NG:

- balances fluctuating power
- adjusts to fluctuating heat demand

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Pilot Plant

A pilot plant will require a budget about 75 % bigger than a plant produced in series, allowing for

- coordination of all components
- trouble shooting in the test phase (estimated 7 - 12 months)
- fine-tuning of the plant

Advantages for investors

1. First option for other plants produced in series and, even more important, for a scale-up plant (> 500 MW) with an even higher return of investment
2. Substantial pioneer profits in the first years
3. Short capital commitment period with serial plants (< 2 Jahre)
4. A comparable prototype (similar technology) already operates profitable at current market conditions (low risk investment)

Advantages for gas providers (possible cooperation partner / investor / operator)

1. more independence / less external purchases / admixtures / economies of scale / flexible utilisation of resources
2. Better margins, optimised utilisation of the EEG
3. Long-term competitive advantage (lower energy prices)

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Thermochemical Gasification of Biomass – a Mature Solar Power Station

- robust
- affordable
- available
  - by day and night
  - irrespective of weather
  - summer und winter time
  - according to demand
- high potential
  - substitutes nuclear and fossil energies
  - can be installed worldwide
  - zero emissions
  - CO_2-neutral
  - secures nourishment
  - secures water supply
  - saves our environment
  - substantial (pioneer) profits

we know how it works

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Bio-Hydrogen or DESERTEC?

Production and delivery of bio-hydrogen energy to the customer is considerably cheaper than energy produced by the DESERTEC system. At H_2 Patent we firmly believe that a combination of both forms of energy would be a mutually beneficial synergy, offering maximum efficiency. This is especially valid for arid and sunny environments.

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Water = Energy = Water

Water can produce bio-energy.

This bio-energy can produce at least three times more (desalted) water.

This water can produce more bio-energy, producing more water …

Bio-Hydrogen: a magic formula

In an arid environment about 5 kg of vegetal biomass can be nurtured with 1 m^3 of water. If you wish to desalt sea water you will need about 1.5 kg of this biomass for 1 m^3 of ocean water.
The formula in short: with an input of 1 m^3 of (rain)water you can nurture enough biomass to desalt more than 3 m^3 of sea water.

…a magic kind of perpetual motion machine...

Alternatively, solar heat (parabolic trough) can be used to desalt sea water . This can then be used to nurture energy crop plants which in turn serve as the basis for the implementation of a sustainable hydrogen economy even in arid environments.

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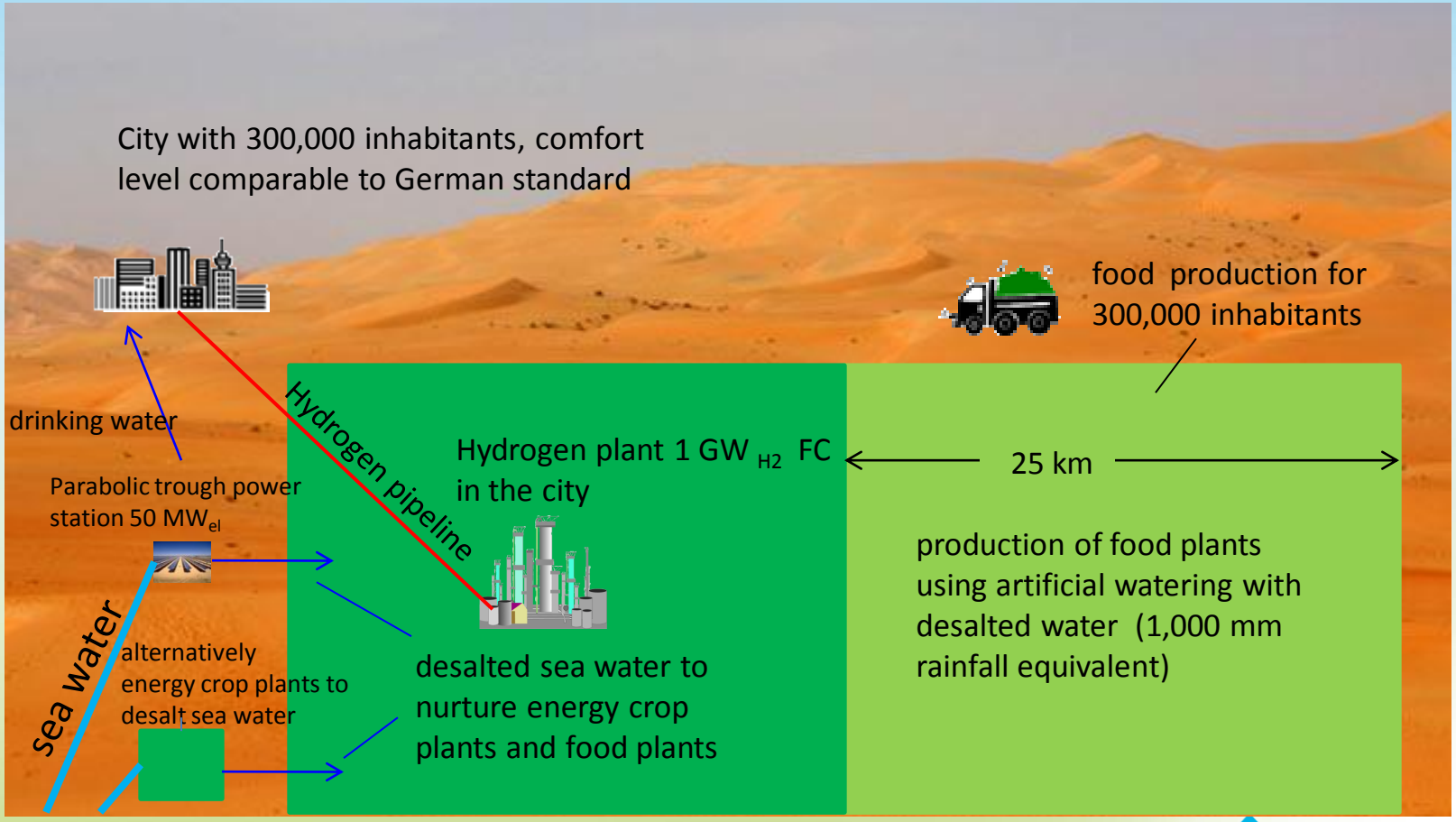
Hydrogen Infrastructure for a Modern Oasis



The scheme shows the relative sizes necessary to fully provide a city in the desert with food, water and energy. The target standard is that of a comparable German town.

The entire supply, as shown, is cheaper than the traditional supply today.

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Combination of Parabolic Troughs and Bio-Hydrogen in Arid Regions / Deserts

- The energy retrieved with parabolic troughs is suitable for desalting sea water (area needed in comparison to bio-hydrogen technology merely ⅛)
  + with heat (multiple flash) + with electricity (reverse osmose) + with a combiation of both technologies
- Half of the water will be used for the nurturing of energy crop plants, the other half for food plants.
- The Hydrogen energy produced from biomass is about 10 times greater than the energy used to produce (desalted) water.
- Hydrogen is utilised at night in order to ensure a continuous production and availability of (desalted) water.
- A city of 300,000 inhabitants can with this technology be fully provided for. All needs are met: drinking water, food, electricity, heat and /or cooling media and fuel.
- A genuine Hydrogen infrastructur is more cost-efficient than a traditional infrastructure based on electricity. There is an extremely favourable overall balance in comparison to any traditional form of energy production.

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Parabolic Troughs in a Hydrogen Economy

- Parabolic troughs can simply be used as and when the sun is shining
    - In a Hydrogen economy any fluctuations of other forms of energy supply can easily be compensated.
- All of the energy produced by the parabolic reflectors can be used for its designated purpose
    - None of the energy has to be converted to electricity as (more than) sufficient energy is produced by the Hydrogen economy.
- The water used to clean the parabolic reflectors can afterwards be used for the nurturing of energy crop plants.

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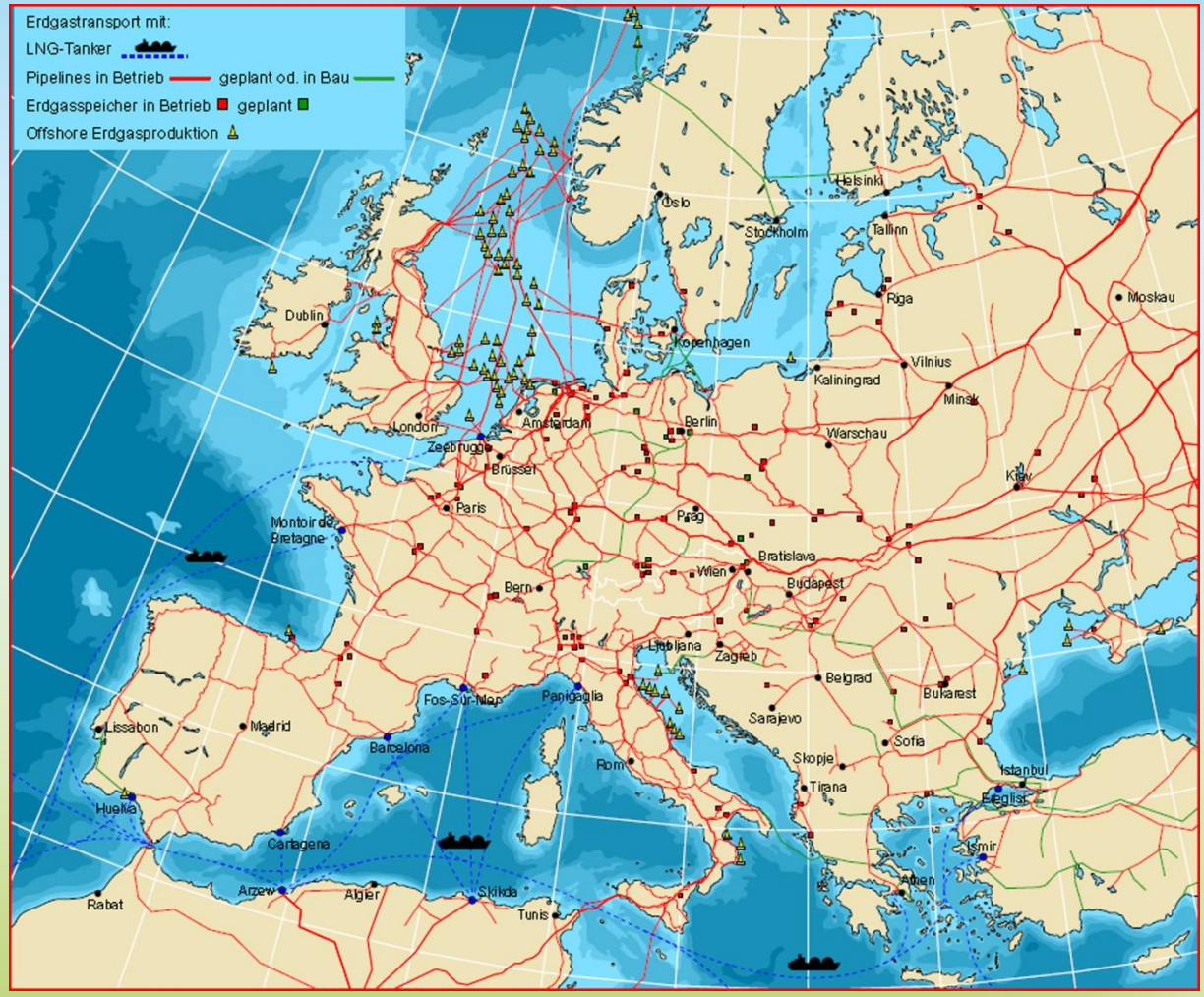
Network of Gas Pipelines



The infrastructure to implement a genuine Hydrogen economy is by and large existent.

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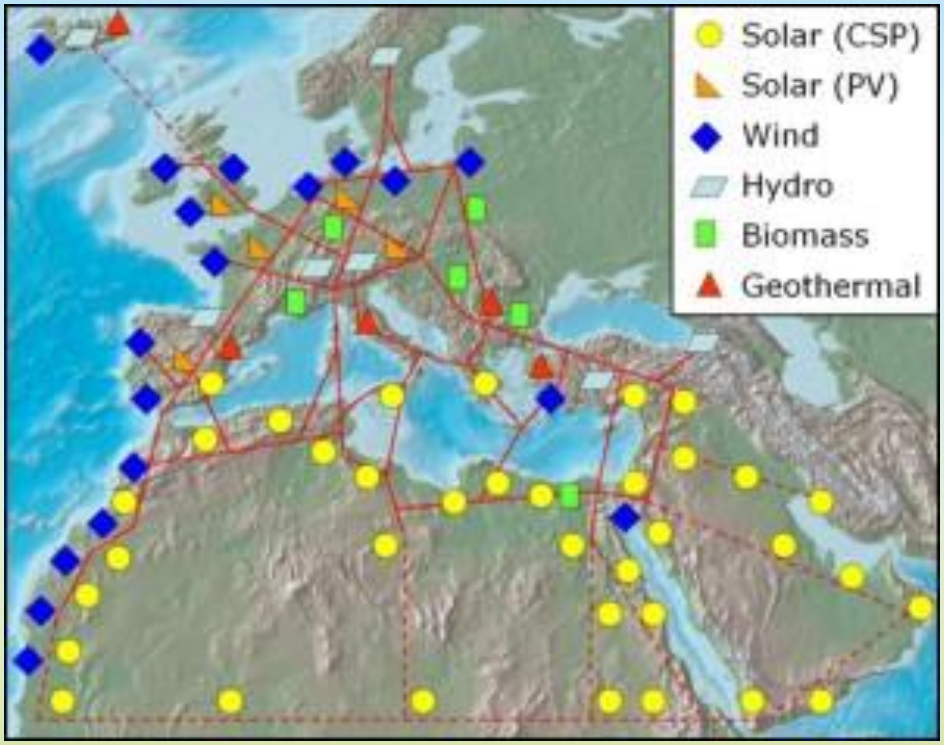
DESERTEC



Electricity network
according to DESERTEC

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