OPTIONS FOR A MEDIUM AND LONG TERM SUSTAINABLE ENERGY SUPPLY IN EUROPE

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LONG TERM ENERGY SUPPLY

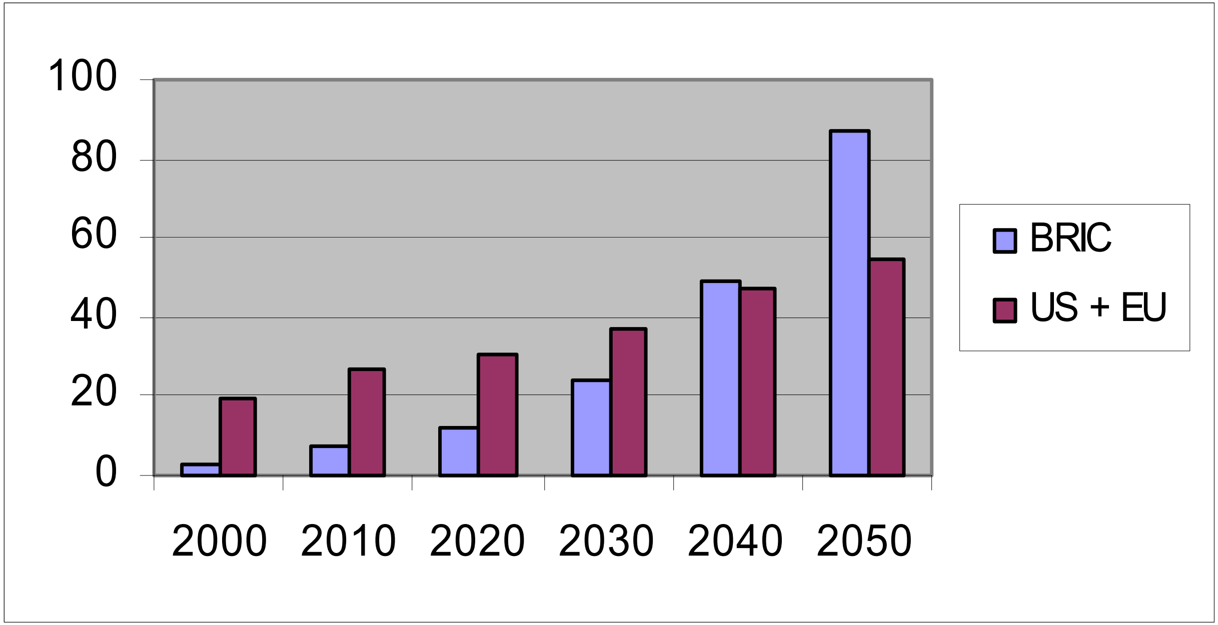
Drivers for a sustainable energy supply are:

- ✓ Security of energy supply; in particular for oil of which the share in the EU and CH final energy supply is 45.7 % and 58% respectively
- ✓ Reduction of CO_2 emissions (Kyoto)
- ✓ Pollution abatement.

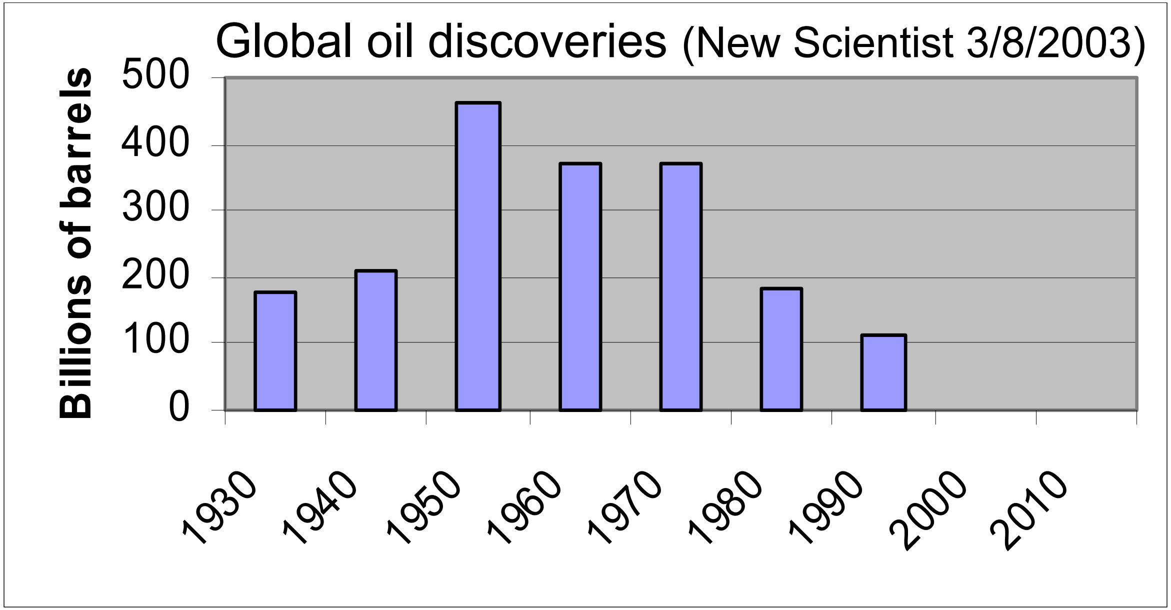
GLOBAL OIL RESERVES 2001 (BP)

World Res. Gtoe	World prod. Gtoe	Reserves in years	EU	Former Sov. Union	Middle East	China	India	Australia	Japan	North Am.	S&C Am.
143	3.52	40.6	2.3%	7.5%	65.4%	1.7%	0.5%	0.3%	0.0%	4.8%	9.40%

GDP until 2050 in trillions of 2003 dollars for US+EU and Brazil+Russia+India+China (Goldman and Sachs)



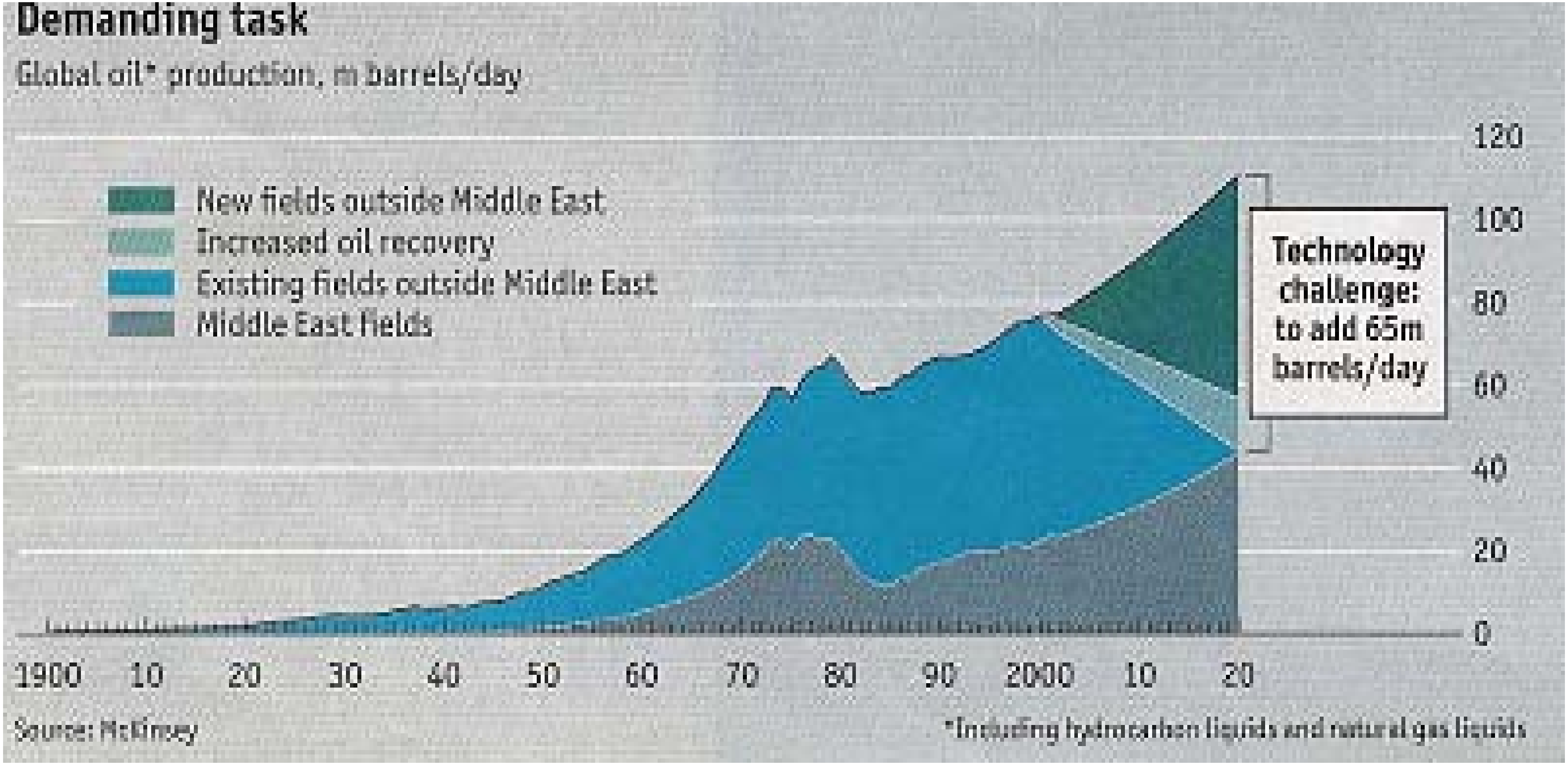
THE END OF OIL DISCOVERIES



- ✓ Today for every 4 barrels we consume 1 new barrel is discovered;
- ✓ We have come to the end of oil discoveries;
- ✓ We have used a bit less than half of the available oil;
- ✓ Cheap fields are finished; development of new fields will be expensive (deep sea drilling down to 2000 m in 2010);

GLOBAL OIL PRODUCTION UNTIL 2020

(The Economist 8/12/2001)



Cost to cover the gap of 65m barrels/day by 2020 is expected to be 1 and 2.2 trillion $ in IEA estimates of 2001 and October 2003;

RISKS FOR SECURITY OF OIL SUPPLY

Until 2010

- ✓ Will these investments be made in time? If this process is too slow, this will lead to shortage, high prices and unfriendly competition;
- ✓ A large and increasing share of oil comes from the unstable Middle East;
- ✓ Some experts expect that oil supply problems will start around 2006 (volatile oil prices, three oil related wars in 10 years).

From 2010 to 2040 years

Oil reserves are limited and will last much less than 40 years in view of the rapid growth of the GDP in particular in BRIC countries.

The demand for energy will be so large, that we will need all the resources we have.

Actions aimed at decreasing the dependence on oil

- ✓ Both the EU and the US are giving strong political and financial support to an increased role of hydrogen from natural gas and coal;
- ✓ Car industry is spending billions of Euros on research related to fuel cell driven cars: fuels from natural gas and RES, two times higher efficiency, clean;
- ✓ Oil companies become energy companies (Shell, BP);

OIL, COAL AND NATURAL GAS (BP)

	World Reserves Gtoe	World Prod. Gtoe	Reserves years	Percentage of reserves in world regions							
				EU	Former Sov. Union	Middle East	China	India	Australia	North Am.	South Am.
Oil	143	3.52	40.6	2.3%	7.5%	65.4%	1.7%	0.5%	0.3%	4.8%	9.4%
Nat. Gas	134	2.04	66	3.1%	36.0%	36.0%	0.9%	0.4%	1.6%	4.6%	4.5%
Coal*	350	2.24	156	12.7%	23.4%	0.2%	11.6%	8.6%	8.3%	26.6%	2.2%
* Not including sub-bitumous and lignite											

COAL

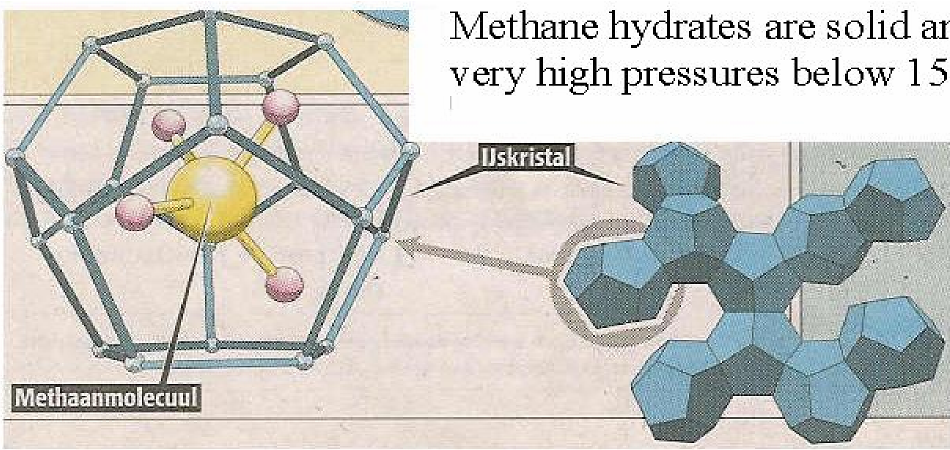
- ✓ Secure, very diversified and cheap and may last 156 years with the current coal consumption.
- ✓ But: two times higher CO_2 emissions per MJ than natural gas
- ✓ Only suitable for large scale energy transformation into hydrogen or electricity;

NATURAL GAS

Advantages

- ✓ It is more diversified than oil (Russia and Middle East have each 36% of the world reserves);
- ✓ Remaining estimated ultimate resources (EUR) for gas (323 Gtoe) are 40% higher than those of oil (230 Gtoe) and continue to increase whereas EUR of oil is levelling off (BGR,D).
- ✓ In the long term the huge methane hydrate resources in oceans (1000-3000 m depth) may be tapped (20 times those of conventional gas + oil + coal).

Methane hydrates are solid and stable at very high pressures below 15 ^{0}C

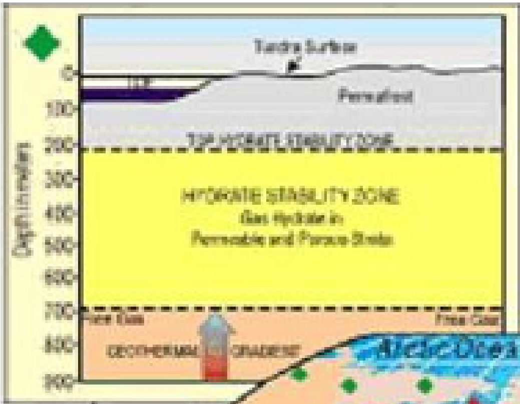


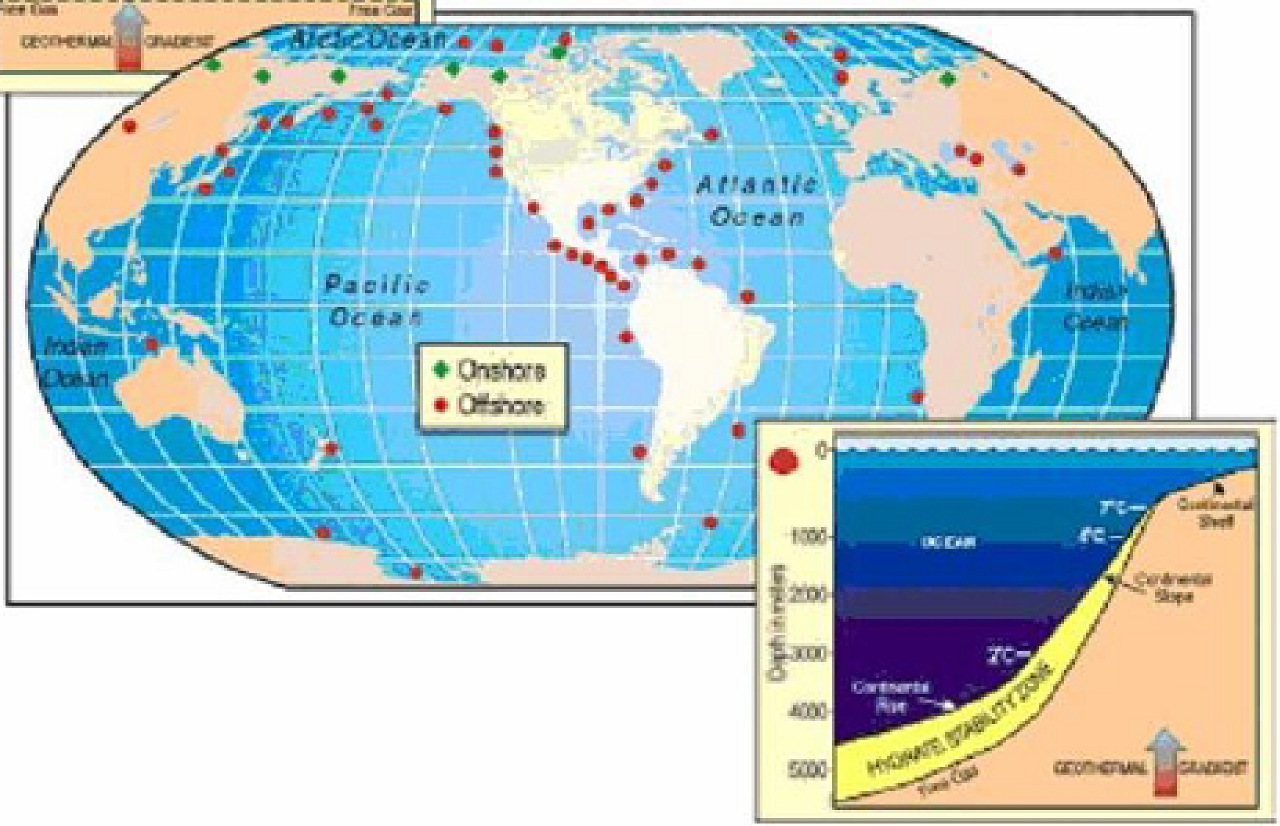
METHANE HYDRATE DEPOSITS (DOE)

Hydrate reserves amount to 20 times the combined reserves of oil, coal and gas.

However:

- A large part of the hydrates is dispersed in the sediment
- Extraction at 1000-3000m is very difficult





Nuclear Energy (Fission)

- ✓ Nuclear fission provides 6.5%, 15% and 24% of the global, EU and Swiss primary energy respectively.
- ✓ Global uranium reserves are sufficient for 40 years with current power production; at higher cost very large resources are available;
- ✓ Nuclear fission could be an important source of sustainable electricity or hydrogen;
- ✓ The cost of nuclear electricity is estimated 4(France) and 6 €cent/kWh (US MIT study 2003) as compared to 4 €cent with natural gas;
- ✓ The possibilities for thermo-chemical production of hydrogen with HTGR fission reactors, which operate at 900 ^{0}C, might be explored.

OPTIONS FOR A MORE SECURE AND SUSTAINABLE MEDIUM AND LONG TERM EU ENERGY SUPPLY

Two main scenarios which partly overlap and complement each other:

- ✓ Sustainable use of fossil fuels including CO_2 sequestration and energy saving (2000 – 2030);
- ✓ A largely RES based EU energy supply (beyond 2030).

MORE SECURE AND SUSTAINABLE FOSSIL FUEL BASED EU ENERGY SUPPLY

More secure

- ✓ Reduction of oil and increased use of natural gas, RES, RUE and possibly coal and nuclear;

Sustainable:

- ✓ Clean electricity production with CO_2 capture and underground storage;
- ✓ Large scale production of clean hydrogen from natural gas and possibly coal with CO_2 capture and underground storage;
- ✓ Clean use of energy in particular by an increased role of fuel cells.

CO_2 SEQUESTRATION - "CLEAN" ELECTRICITY

1 Remove CO_2 from the exhaust gases of large fossil fueled electricity plants (post combustion) and store it underground

- An increase of the electricity cost of 50% for natural gas (40 €/ton CO_2);
- Can be reduced to 20% in 5-10 years;
- 80% of this cost increase is for capture of CO_2;
- 500-1000 MW plants; CO_2 sequestration too expensive in small plants due to economy of scale;

2 Make clean hydrogen first (pre combustion), from natural gas reformers and CO_2 sequestration. Use hydrogen in gas/steam turbines to get "clean" electricity :

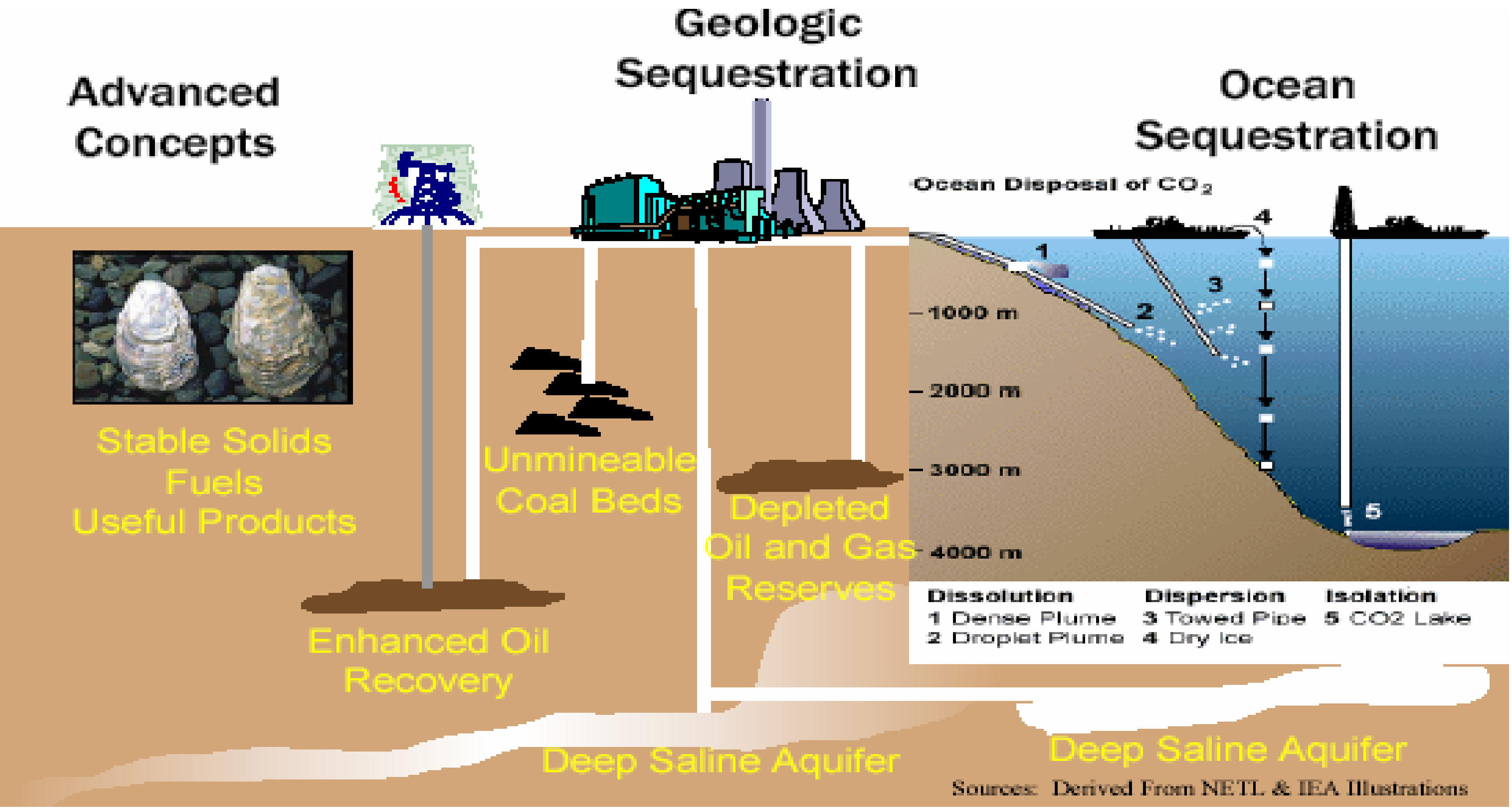
- Cheaper; with time, the cost increase for electricity could come down to 20%;
- Hydrogen can also be used for other purposes (e.g. transport, fuel cells);
- Allows cleaning of hydrogen down to ppm (important for use in fuel cells).

These techniques have the potential to reduce EU CO_2 emissions by 30%.

For Switzerland with 95% of clean electricity, the priority for CO_2 seq. is lower.

Only with legal incentives such as CO_2 tax (e.g. 30 €/ ton CO_2 in Norway) the necessary investments will be made

CO_2 STORAGE



CO_2 storage capacity in the EU is sufficient for 300 years of current total EU annual emissions (aquifers, depleted oil and gas fields)

"CLEAN" HYDROGEN

"Clean" hydrogen from offers:

1) A greater security of supply;
2) Near to zero CO_2 and pollutant emissions;
3) Same energy carrier both before (NG) and after 2030 (RES).

HYDROGEN PRODUCTION

Many sources;

Reforming of natural gas

In 5 – 10 years the cost of hydrogen from NG with CO_2 sequestration could be 6 €/GJ for 400 MW and 9 €/GJ for 100 MW plants:

This is competitive with prices for petrol/Diesel without tax (10 €/GJ); in particular for use in fuel cells (two times higher efficiency than petrol engines).

Biomass gasification

Future costs of hydrogen from biomass gasification will range from 10 to 14 €/GJ. A problem is the cleaning of hydrogen for use in fuel cells (tars).

From RES with electrolysis

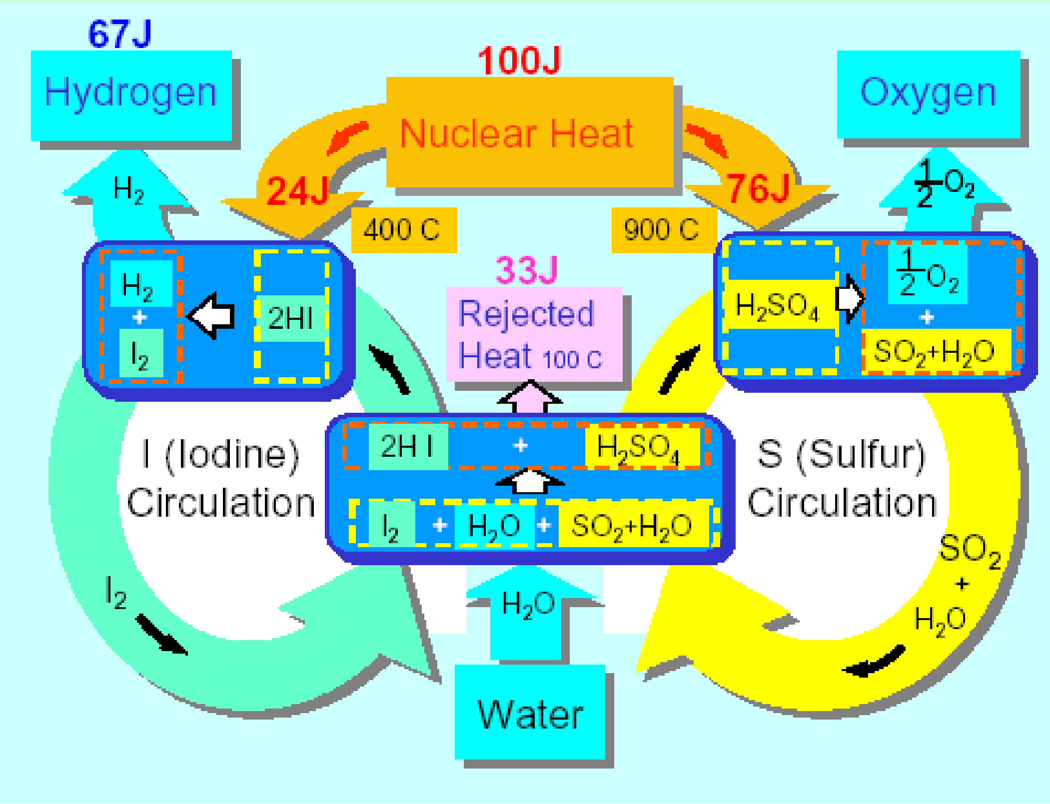
Nuclear fission

Thermo-chemical production of hydrogen in a HTGR.

NUCLEAR HYDROGEN PRODUCTION BY HTGR (Japan)

R&D on Thermochemical IS Process

- More than 4000℃ necessary for pyrolysis of water
- Pyrolysis with water and heat of 900℃ by three chemical reactions



Subjects

- ✧ Close cycle test
- ✧ High-efficiency test
- ✧ R&D on material with anti-corrosion

$$2HI \rightarrow H_2 + I_2$$

$$H_2SO_4 \rightarrow 1/2O_2 + SO_2 + H_2O$$

$$I_2 + SO_2 + 2H_2O \rightarrow 2HI + H_2SO_4$$

$$+$$

$$H_2O \rightarrow H_2 + 1/2O_2$$

HYDROGEN STORAGE AND DISTRIBUTION

Hydrogen storage is a key problem for fuel cell applications.

Both storage of liquid and compressed (700 bar) hydrogen is possible; both options have about the same energy content per liter and are close to the market;

Energy losses: liquefaction 40%; hydrogen compressed to 700 bar 13%.
Compressed hydrogen is favored; range of 500 km for a car is possible;

Research is needed on other concepts such as:

- ✓ Small scale hydride and nano technology;
- ✓ Large scale storage of compressed hydrogen in caverns, salt mines and empty NG wells (US NREL investment cost estimate 20 €/kg hydrogen),

Cost of hydrogen transport by pipeline (US NREL)

Hydrogen source	Quantity kg/hr	Distance km	Cost €cent/lpe
Natural Gas	1.000 (33 MW)	16	2
Nuclear HTGR	20.000 (660 MW)	160	1.5
Import	40.000 (1320 MW)	800	2.5

Cost of compression to 700 bar adds 8 €cent per lpe.

Total cost of hydrogen in the car tank will be 10-20% higher than tax free petrol

“CLEAN" ENERGY USE - FUEL CELLS

Fuel cells are a new promising technology for transport, decentralised electricity production and cogeneration due to:

- ✓ Higher efficiency;
- ✓ Low or zero pollution;
- ✓ Potential for low cost

Large potential for energy savings:

- ✓ 50% in road transport (30% of final EU energy)
- ✓ 30 - 50% for production of low grade heat (40% of EU final energy)

Hydrogen is used as a fuel.

Other fuels such as NG, methanol, petrol, Diesel need to be transformed into hydrogen first with a reformer.

PEMFC: 80^{o}C, 40 – 50% efficiency, car-traction, co-generation in buildings

SOFC: 700^{o}C, 40 – 70%, co-generation in buildings and industry, power plants

FUEL CELLS FOR CAR PROPULSION - COST

No market for fuel cells yet; existing fuel cell systems are handmade at a high cost of around 3000 €/kW.

PEMFCs have, if mass produced, the potential to become cheaper than internal combustion engines for cars (< 50€/kW):

- ✓ Simpler structure;
- ✓ Number of different components is smaller;
- ✓ Low Pt load and cost;
- ✓ Patents for electrolyte membranes expire.

80 kW Ballard stack (volume 77 liters)

Car industry is spending billions on PEMFC research; targets are:

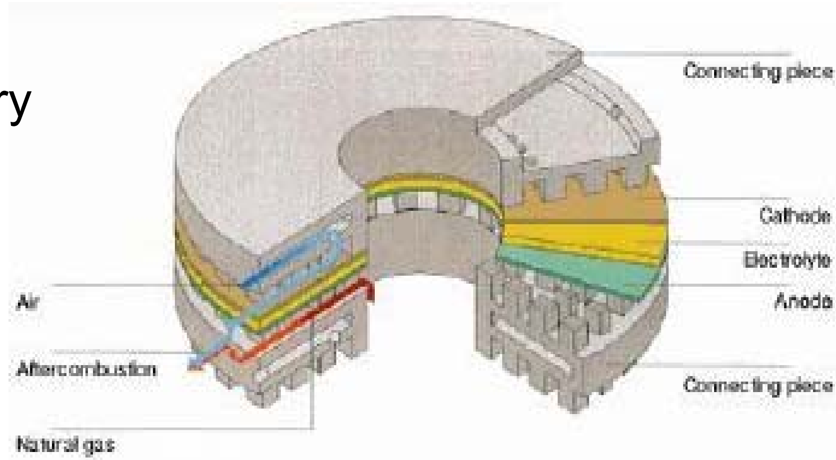
- ✓ A cost of 50 €/kW; series production by 2010 (US GM);
- ✓ A 2-3 times higher “well (NG) to wheel” efficiency than for petrol engines(Toyota);
- ✓ Hydrogen cost only 10-20% higher than a litre petrol equivalent (lpe)

FUEL CELLS FOR STATIONARY APPLICATIONS - COST

If a cost of 50 €/kW for PEMFC car traction could be realised these fuel cells will be very competitive for:

- ✓ Electricity production (600€/kW);
- ✓ Cogeneration in buildings and industry 300 – 500 €/kW)

Also more expensive SOFC will be here competitive

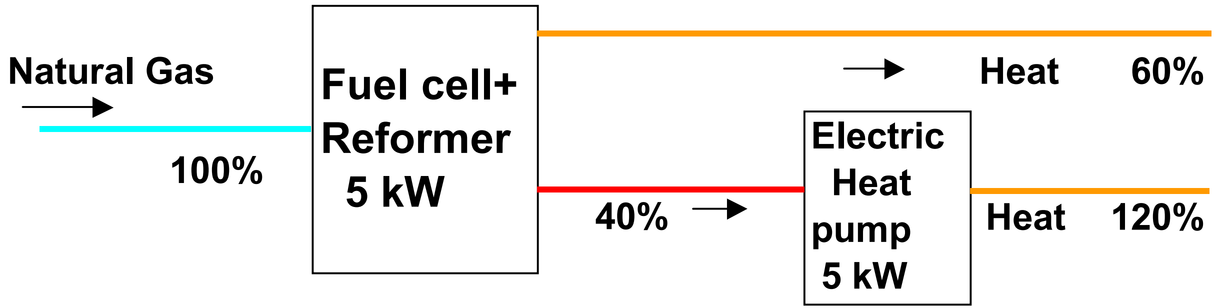


SOFC for co-generation of Sulzer Hexis

Co-generation for households:

- ✓ 10 kW, 40% electricity and 60% heat of 70 ^{o}C (PEMFC);
- ✓ FC can cover around 25% heat demand of households (heat/ electricity ratio is 5);
- ✓ NG boiler remains necessary or a heat pump.

FC design for heat demand with heat pump

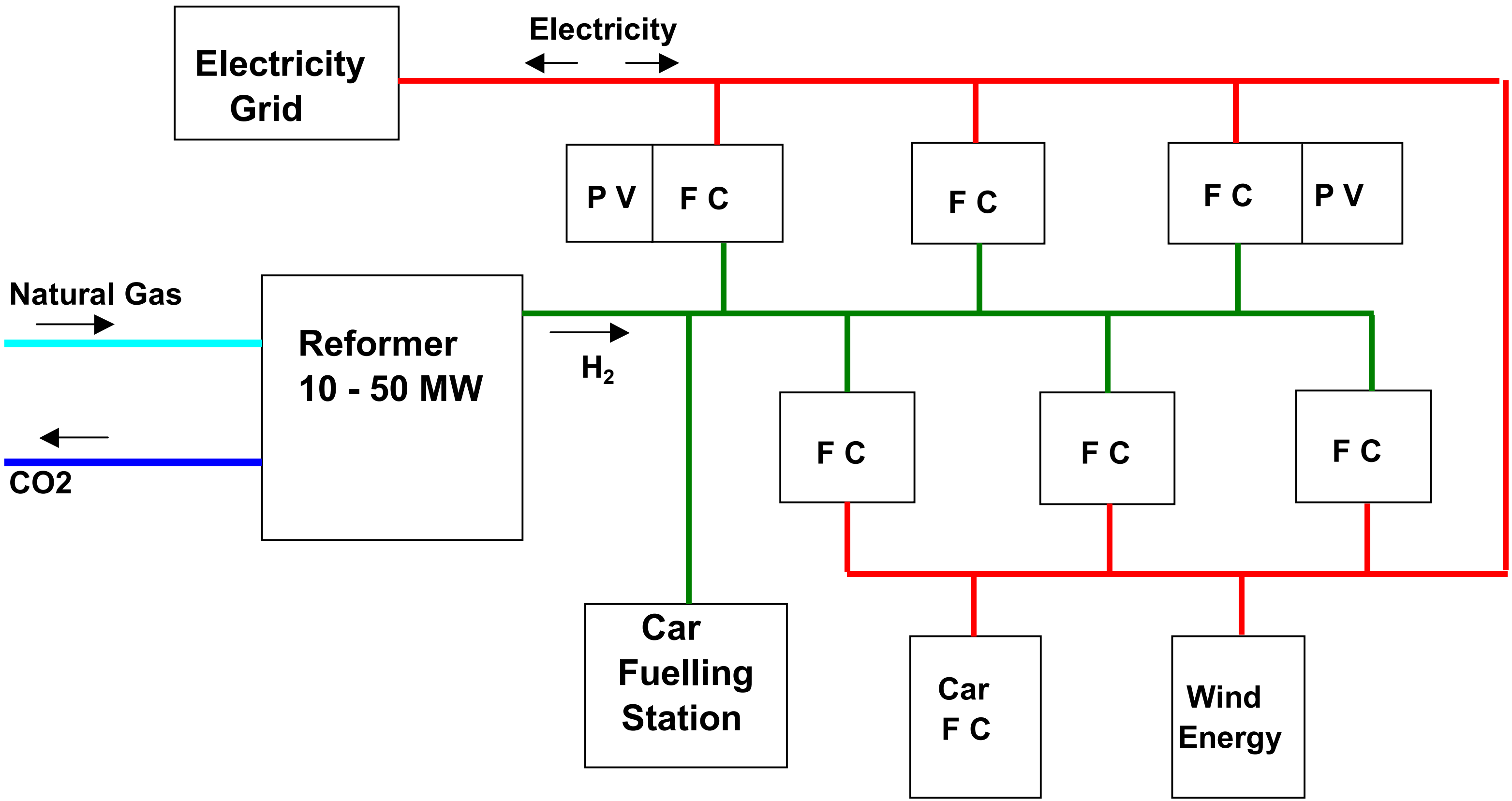


- ✓ 45% energy savings and lower CO_2 emissions for NG heat production;
- ✓ As compared to oil heating a reduction of 67% in CO_2 emissions;
- ✓ Air conditioning without extra investment.

Cogeneration with fuel cells could also be very attractive in;

- ✓ Office buildings with a heat/electricity demand ratio of around 1.5 (the same as fuel cells);
- ✓ SOFC with waste heat of 500^0C could be interesting for industry;

VIRTUAL POWER PLANT – A LONG TERM VISION



A "communication" grid which connects all energy users and producers is key to the success of a VPP.

VIRTUAL POWER PLANT

Cheap: in 5 – 10 years the cost may be as low as 200 - 300 €/kW (Reformer + FCs), compared to gas/steam turbines (600 €/kW);

Security of electricity supply

- ✓ VPPs add power generation capacity without increasing the capacity of the electricity infrastructure; increased security by mutual back-up
- ✓ Gas transport is cheaper and less accident prone, than transport of electricity;
- ✓ Natural gas and hydrogen pipelines allow storage by changing the pressure;
- ✓ Local back-up of intermittent RES avoids the need to increase reserve capacity of central electricity production;

Synergy between transport and stationary applications

- ✓ Hydrogen produced by the reformer can also be used for car and bus traction;
- ✓ The cost of the hydrogen infrastructure is shared by stationary and transport fuel cell applications;
- ✓ Use could be made of fuel cells in cars as reserve capacity;

RTD FOR CLEAN FOSSIL BASED ENERGY SUPPLY

CO_2 sequestration

- ✓ Determine capacity and geological stability of underground CO_2 storage;
- ✓ Explore possibilities of binding CO_2 to rocks (olivines);
- ✓ Decrease cost of capturing CO_2 from exhaust gases of power plants;
- ✓ Cost reduction of reformers for hydrogen production from NG; in particular in the range of 50 MW
- ✓ Non-technical barriers e.g. safety;
- ✓ CO_2 tax or similar measures (In Norway a CO_2 tax of 30 €/tonne);

Fuel cells

- ✓ Development of cost-effective PEMFC and SOFC for transport and stationary applications (life, corrosion, higher tolerance for impurities);
- ✓ Study concepts such as Virtual Power Plants;
- ✓ Integration of fuel cells with heat pumps;
- ✓ FC back-up of PV and wind energy

Hydrogen

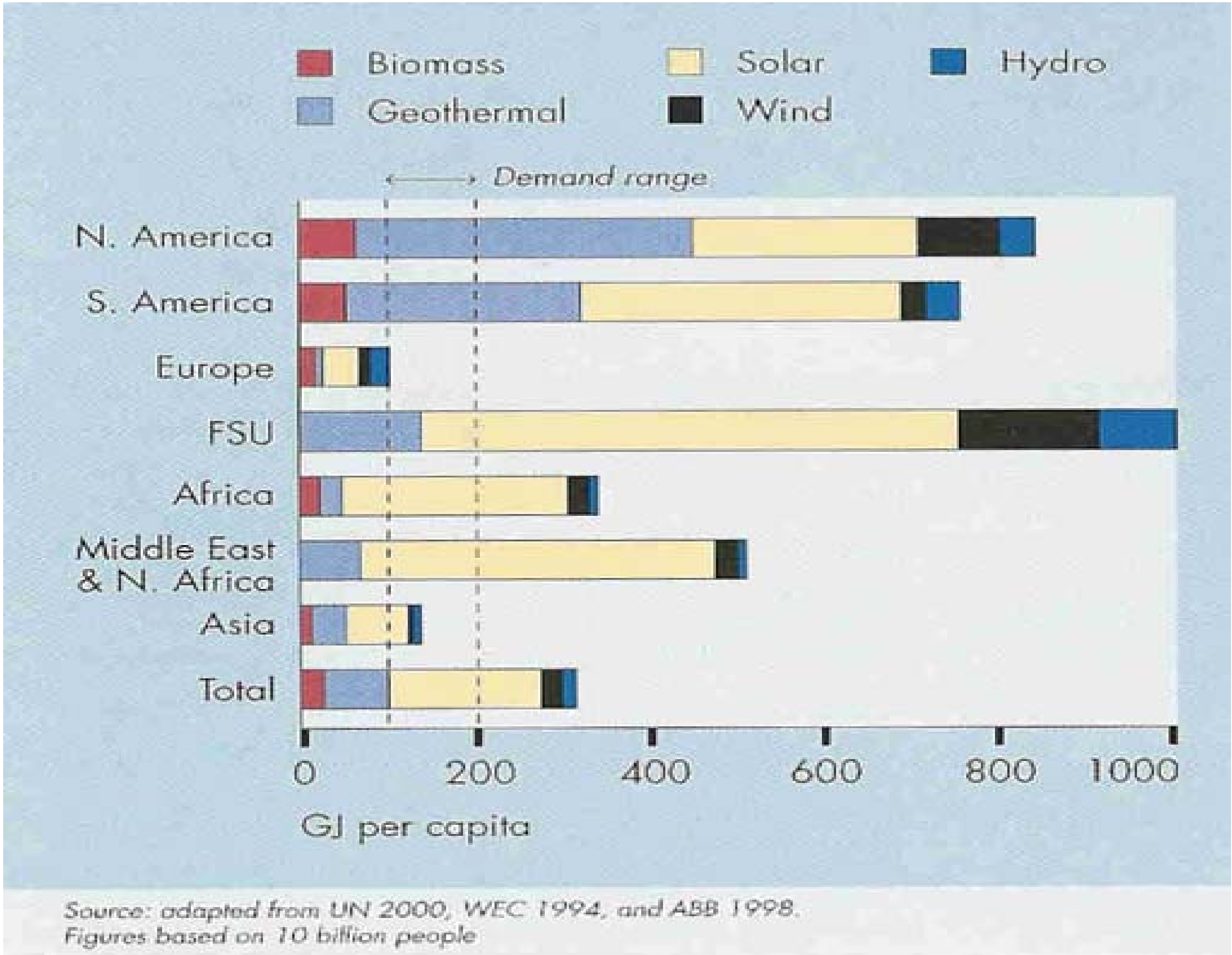
- ✓ Cost-effective H_2 storage (e.g. hydrides, nano technologies, large scale in caverns, salt mines or abandoned NG wells);
- ✓ Find ways to adapt NG pipelines to hydrogen transport (coatings,additives).

A LARGELY RES BASED ENERGY SUPPLY (BEYOND 2030)

Key questions :

- ✓ Is the RES potential sufficient to cover energy demand
- ✓ Can RES be competitive with conventional energy sources.

POTENTIAL FOR RENEWABLE ENERGY
(Shell energy scenarios 2050)



The current per capita EU and Swiss annual energy use is 105 and 115 GJ

PHOTOVOLTAICS

PV is attractive as it could, in theory, cover the total energy demand.

The EU PV capacity doubled every 3 years during the last 10 years;

The current share of the EU electricity production is still only 0.15 %.

Major bottleneck is a too high cost: 25 - 50 €cent/kWh versus (current prices

4 and 10 €cent/kWh off plant and at the user respectively.

Potential for cost reduction to 6 -10 (possibly 3-5 €c/kWh):

- ✓ Reduction of module and system costs by a factor 4 by mass production and new low cost cells (dye sensitized cells promising (Prof. Graetzel);
- ✓ Increase efficiency of 10-16% (double in long term);
- ✓ Give priority to PV on roofs (close to the user, lower system costs);
- ✓ Air conditioning
- ✓ Long term potential 50-100% of the EU electricity production.

Intermittent power supply is a major problem

Hydrogen from photo-electrochemical processes: efficiency 1% → 8%

WIND ENERGY

The EU electricity production capacity with wind doubled every two years during the last ten years.

Potential

The current share of the EU electricity production is still only 2.3 %. EWEA expects 4 - 5% and 20% in 2010 and 2020 respectively

- ✓ The BWEA estimates that Britain alone can cover 100% of the EU power demand;
- ✓ Wind Force 10 predicts a final long term potential of 40% of the EU power production; taking into account non-technical barriers.

Major bottleneck is cost:

- ✓ Current cost 4 - 9 €c/kWh versus current electricity prices of 4 and 10 €c/kWh off plant and at the user respectively.
- ✓ Much scope for cost reduction (3 - 5 €c/kWh);

Intermittent character of wind energy is a major barrier; production of hydrogen for fuel cells, could be an option

BIOMASS

Biomass currently covers 5% of the EU energy demand mainly heating.

Drawback wide variety of raw materials and conversion technologies and an even larger variety of combinations with each its own problems.

The long term EU potential could be 280-400 Mtoe;

- ✓ 180 M toe forest and agricultural waste;
- ✓ 20. 10*6 ha for fuel crop with a yield of 5 toe/ha (target in 10 toe/ha);
- ✓ There is also a considerable potential in new member states

This could transformed into:

- ✓ 110 – 160 M toe electricity or
- ✓ 140 - 200 M toe liquid fuels (target cost 12 - 18 €/GJ) or
- ✓ 200 – 280 M toe hydrogen (target cost 10 -14 €/GJ)

Use biomass for transport applications:

- ✓ Security of supply;
- ✓ Hydrogen or bio fuels are the only options for reduction of CO_2 in transport

MEDIUM AND LONG TERM RES RTD

PV

- ✓ Cost reduction with long term cost target of 5-10 €cent; cheap mass production, cheap cell types, etc
- ✓ Application of PV modules for roofs and facades (e.g. PV construction products, aesthetics);
- ✓ Basic materials research to improve PV efficiency;
- ✓ Hydrogen production with photo-electrochemical processes;

Wind

- ✓ Cost reduction with a target cost of 3-5 €cent/kW ; in particular by larger
  wind turbines (5 MW); economy of scale;
- ✓ Material research for stronger wings;
- ✓ Improved aerodynamics.

Biomass; focus on hydrogen from biomass by gasification

- ✓ Cost reduction; cost target for hydrogen 10-14 €cent/GJ;
- ✓ Avoid or remove tar syn gas;
- ✓ Possibly production of bio fuels from syn gas by Fischer-Tropsch process

Development of cheap and efficient electrolysers

LONG TERM RES POTENTIAL IN % OF CURRENT EU POWER DEMAND (+/- 2500 TWh) AND COST (€c/kWh)

	Current share (rate of annual increase)	Long term potential	Current cost of electricity	Target long term electr. cost
PV	0.15% (30%)	50-100%	25 - 50	6 - 10 (3 - 5)
Wind	2.3% (40%)	40 -100%	4 - 9	3 - 5
Biomass	5% of total energy	50-80%	4 - 8	3 - 5
Geothermal Hot dry rock	na	20% + heat	12	4
Solar Therm.	na	20%	12	4
Hydro	12%	17%	2-3	2-3

- ✓ Conventional electricity cost: off-plant 4 and 5 €cent/kWh (without and with CO_2 sequestration); nuclear 6 €cent/kWh; at user 10 €cent/kWh
- ✓ RES mainly electricity; EU final energy demand 20% electricity, 80% fuels for heat
- ✓ Intermittent electricity supply of PV, wind a major problem; hydrogen production for FC transport and cogeneration + hp could solve this.

ELECTROLYSERS KEY IN A RES BASED ENERGY SUPPLY

If fuel cells come down to 50-200€/kW, electrolysers (reversed fuel cells) will be cheap too. Current cost 3000 €/kW; long term target 200 €/kW.

- ✓ Electrolyser efficiency of 90% (HHV); in 5-10 years 95%;
- ✓ At present, hydrogen production cost consists for 80% of electricity cost in continuous operation (at 3000 €/kW);
- ✓ This will also be the case for PV and wind with an electyrolyser cost of 200 €/kW in spite of power availability of only 1000 to 2500 hours/year;
- ✓ RES electricity cost determines the hydrogen cost; with cheap hydro and wind electricity, future H_2 cost could be as low as 10-15 €/GJ ;
- ✓ Efficiency electrolyser/hydrogen storage/fuel cell: 55-60%
- ✓ SOFC based electrolysers are expected to have a 25-30% lower electricity consumption than low temperature electrolysers;

SURFACE REQUIRED FOR DIFFERENT TYPES OF RES TO COVER THE EU AND SWISS ELECTRICITY DEMAND

	Electricity per Km^2 in GWh/y	Surface (km^2) needed for EU power demand (2500 TWh)	Surface (km^2) needed for Swiss power demand (55 TWh)	Dual Use of Land
PV	150 - 100*	16.000 - 25.000	370-550	yes (roofs)
Wind	50 - 10**	50.000	6000	yes
Biomass	2	$1.2\ 10^6$	27.000	no
Geothermal Hot dry rock	80	30.000	700 (underground)	yes (2 ha/km^2)
Hydro	na	na	na	

* Depending on the annual insolation ranging from 1000 to 1500 hours/year;
** Depending on the density of wind energy (W/m^2)

LONG TERM POTENTIAL FOR RES IN THE EU

EU final energy demand in 2030: 1160 M toe (25% el. and 75% heat).

Potential 200-280 M toe of hydrogen from biomass and 315 – 514 M toe of RES electricity, will not be sufficient to cover demand in 2030.

Ways to close the gap

- ➔ Rational Use of Energy could stretch the RES resources:
  - ✓ FC cogeneration and linked heat pumps could bring about large energy savings, in the building and tertiary sector, of 30-50% (of 460 M toe in 2030);
  - ✓ Fuel cell driven cars could reduce energy use by 50% (of 360 M toe in 2030).
- ➔ Import of RES electricity or hydrogen from Iceland, Sahara, Russia, etc.
- ➔ Hydrogen from fossil fuels (NG):
- ➔ Nuclear electricity and hydrogen (HTGR); if all transport would be FC driven a 1000 MW HTGR could supply hydrogen for 20% of the Swiss transport vehicles.

ENERGY SUPPLY IN SWITZERLAND

The Swiss final energy supply of 20 M toe: 23.4% of electricity, 58% of oil and 11.4% of gas

- ✓ 95.4% of "clean" electricity (hydro and nuclear power) without CO_2 emissions and with high security of supply;
- ✓ Oil forms 58% of final energy (11,7 M toe) and causes 86% of the overall net Swiss CO_2 emissions
- ✓ 50% of the Swiss energy demand is low grade heat;
- ✓ 5.1M toe oil for heating;
- ✓ 33% of final energy is used for transport (6.5 M toe).

OPTIONS FOR SUSTAINABLE ENERGY SUPPLY IN SWITZERLAND

Time delay years	Measure	RUE Meas. %	CO_2 red. Meas. %	Cum. RUE overall %	Cum. overall CO_2 red. %
5 -10	Replace oil for heating by NG	0	33	0	12
10 - 15	All low grade heat FC (NG) + HP	45	45	22.5	32
20 - 30	FC cars: H_2 from NG and biomass	50	67	40	63
	VPPs with CO_2 sequestration	0	100	40	100
30 - 50	Replace NG by H_2 from RES, HTGR	0	100	40	100

Beyond 2010, FCs and VPPs will increase power production capacity without need for an increase of the electricity infrastructure

LONG TERM RES IN SWITZERLAND

Biomass - preferably used for transport

With fuel crop on 3000 km^2 and biomass waste 2 M toe →
1 M toe bio-fuels (15 % conventional cars) or
1.5 M toe hydrogen (45 % of FC cars);

PV

- ✓ Current share in power production 0.02%;
- ✓ PV costs may come down to 5 – 10 €cent/kW but high land costs →
- ✓ PV on roofs and facades of buildings (close to user, FC back-up);
- ✓ With 500 km^2 PV could cover 25 – 50% of the current final energy;
- ✓ Acceptability and aesthetics are key issues;
- ✓ Intermittent supply is a problem, production of hydrogen could be a solution

Wind

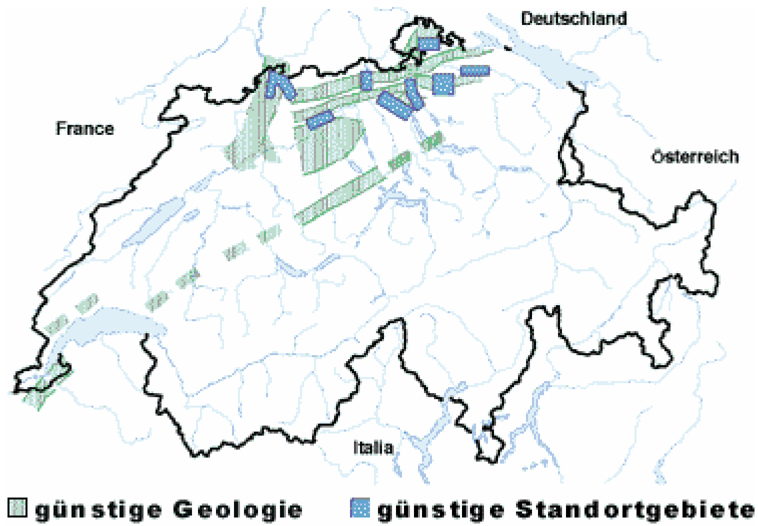
The potential of cost-effective wind energy depends strongly on the average energy density (W/m^2), which in Switzerland is up to 5 times lower than in coastal areas. Areas with high wind speed should be identified.

LONG TERM RES IN SWITZERLAND

Geothermal HDR

175 km^2 (underground) could supply 25% of electricity demand (and 4 x as much low grade heat).

Not intermittent, continuously available



Hydro power

The current supply (13% of the current final energy) can probably not be increased much

CONCLUSIONS

- → The dependence on oil should decrease;
- → For sustainable energy production with natural gas, two technologies will be indispensable: cost-effective
  - CO_2 sequestration and
  - Fuel cells
- → Fuel cells with H_2 from NG may, in the medium and long term, replace:
  - Combustion for low grade heating;
  - Petrol/Diesel engines in road transport;
  - Centralised power production (in buildings and industry).

  and could bring about large energy savings and reductions in CO_2 emissions;
- → RES will, in the long term, become competitive with conventional fossil fuel based energy production;
- → For introduction of RES there are also major non technical barriers.