THE POTENTIAL FOR THE PRODUCTION OF HYDROGEN FROM RENEWABLE ENERGY SOURCES IN AUSTRIA

LA CAPACITE DE PRODUIRE UHYDROGENE UTILISANT DES SOURCES D'ENERGIES RENOUVELABLES EN AUTRICHE

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1. Sustainability of energy systems
La durabilité des systémes énergétiques

Achieving sustainable development is a target that is becoming more and more important to worldwide public opinion. Nevertheless, in the near future even the most progressive countries will be providing for the majority of their energy needs by the exploitation of fossil resources. Some of these countries, however, will re-think conventional energy strategies. In part because of this, significant work in $C0_2$ removal and sequestration is now taking place, with the aim of producing comparatively low-cost hydrogen from fossil fuels with minimal greenhouse gas emissions [1,2]. The life of the reserves /resources of fossil fuels depends of course on the growth rate of energy consumption which can be affected by a number of factors the first of which is the efficiency of energy use. The second factor determining the sustainability of the system is the contribution of renewables which are by nature sustainable. The third factor are new technologies such as fuel cells and technologies for the recapture of pollutants, particularly carbon sequestration.

Renewable energy sources such as biomass, solar, wind, and hydropower have enormous potential to provide energy services in more sustainable ways, with zero or almost zero emissions of both air pollutants and greenhouse gases, and based on the use of routinely available, indigenous resources. Currently renewable energy sources supply approx. 20 % of the world energy demand. A large percentage of that figure represents traditional biomass, mostly fuelwood used for cooking and heating, especially in rural areas of developing countries. New renewable energy sources (solar energy, wind energy, modern bio-energy, geothermal energy, and small hydropower) contribute about 1 % of total primary energy. Substantial price reductions in the fast decades have brought some of these sources close to competing with fossil fuels, even at current low prices. Wind and solar energy, while still a small percentage of total energy consumption, are growing at a rate of 30 % per year. Modern, distributed forms of biomass seem particularly promising for their potential to provide rural areas with clean, modern forms of energy based on the use of indigenous biomass resources that have traditionally been used inefficiently and in polluting ways. Depletion of fossil fuels and environmental considerations have led engineers and scientists to anticipate the need to develop a clean, renewable and sustainable energy system.

The main problems linked with the use of renewable energy are its intermittent nature and the fact that it cannot be directly used for transport and /or storage. Renewable energies are further fairly not adaptable to the social systems of developed countries, in which the population is mostly urban and in highly concentrated areas. Other barriers are high costs and the lack of an adequate infrastructure and public awareness of the advantages of renewable energies. In order to solve the main problems involved in renewable energies, it is necessary to find an energy vector that will enable us to replace the market currently supplied by hydrocarbons. This new energy vector must act as a bridge between the new sources of primary renewable energies and the various sectors of energy consumption. It must also be economical to produce, easy to transmit and store, renewable and non-polluting, and more efficient than current fuels if possible. Hydrogen has all the qualities one could wish for in this new energy vector, so it is not over-ambitious to foresee that it will play an important role in the international energy panorama within a few decades. The timeframe is, as with any major infrastructure and technology change, unclear. By 2050 up to 50 % of energy generation could come from renewable sources, with hydrogen a significant component in the fuel mix [3].

Worldwide programs like the World Energy Network (WE-NET) project in Japan or the U.S. Department of Energy Hydrogen Research and Development programme aim to establish technologies for constructing a hydrogen energy network on a world-wide scale based on non carbonaceous renewable energies such as hydraulic, solar and wind energies. The system includes hydrogen production through water electrolysis, conversion of gaseous hydrogen into desirable media for transportation, storage and sea-borne transportation and utilization in broad applications including power generation by hydrogen combustion turbine, fuel cells and town gas for households. The WENET program extends over 28 years from 1993 to 2020 [4]. This programmes are aiming toward achieving strategic goals like energy security, environmental security, and international competitiveness. The technology development goals include the improvement of the efficiency and lower the cost of fossil-based and biomass-based hydrogen production processes, advance emission-free, and renewable-based hydrogen production technologies towards commercial viability demonstrate safe and cost-effective storage systems for use in stationary distributed electricity generation applications, and for on-board and stationary applications in urban non-attainment areas and develop fuel cell and reversible fuel cell technologies as an efficient low-cost means of converting hydrogen into electric power. While renewable energy generating capacity begins to be exploited, it may be that carbon sequestration can act as one plank of a bridge to a future renewable hydrogen economy [5]. In some niche markets, such as remote areas, renewably generated hydrogen and fuel cell systems can already be economically competitive [6]. These systems can act as proofs of concept, allowing control strategies to be refined and costs to be reduced before they are integrated into the wider market. The development of remote, renewable-based energy is hindered in part by the lack of affordable energy storage. Requiring power-on-demand from an energy system powered by intermittent or seasonal sources may necessitate one-month's energy storage. If multiple energy storage devices with complementary performance characteristics are used together, the resulting "hybrid energy storage system" can dramatically reduce the cost of energy storage over single storage systems. The coupling of conventional storage batteries with emerging hydrogen technologies provides one such hybrid system [7]. Hydrogen energy storage in this context includes an electrolyser, hydrogen storage tank, and a fuel cell.

California regulations, especially the low emission vehicle (LEV) laws in California, now require major vehicle manufacturers to introduce Zero-Emission Vehicles (ZEVs) with the aim that the added emission reductions from the widespread use of ZEVs would help enable California to ultimately meet its air-quality goals [8]. These legal regulations are currently the driving forces for more intensive technological developments with respect to a global automobile market. In the future, high efficient vehicles at very low emission levels will include low temperature fuel cell systems e.g., polymer electrolyte fuel cell (PEFC) as units of hydrogen-, methanol- or gasoline-based electric power trains [9]. With alcohols, ether or hydrocarbons used as fuels for these new electric power trains, hydrogen as PEFC fuel has to be produced on board. These concepts including the direct use of methanol in fuel-cell systems, differ considerably in terms of both their development prospects and the results achieved so far [10]. The direct use of hydrogen as a fuel is expected to have advantages with respect to fuel-cell technology in terms of a sustainable material and energy supply compared to conventional approaches. If hydrogen could be produced on a non-fossil basis, this would offer an option for overcoming the greenhouse effect [11,12,13]. Another area in which hydrogen will be replacing fossil fuels is air transportation, an area that has been under research for several decades. Hydrogen as an energy carrier for use in airplanes has some unique attributes like global availability, safety, minimum pollution and light weight, making it an ideal fuel. Considerations of fuel availability and of environmental concerns put liquid hydrogen in a very good position to replace jet fuel [14].

If the first fuel cell systems prove successful, then the technology may actually drive replacement faster than has presently been suggested, and may also benefit renewable energy systems as providers of non-fossil hydrogen. Fuel cells could provide low-cost, high-efficiency electric power for stationary and mobile applications. There has been a significant increase in industry activity for the development of PEM fuel cells for vehicular applications, with a number of active demonstration projects. Improvements in catalyst loading requirements, water management, and temperature control have helped to move these power units from mere curiosities to potential market successes. In order to increase the market penetration in both the transportation and utility sectors, additional improvements are required. The most significant barriers are costs, however detailed engineering studies have suggested that the cost of the fuel cell system can be brought down, without the requirement of technical breakthroughs, to a level where it is competitive with the internal combustion engine for mobile applications as well power plants for stationary applications. Numerous demonstration plants have confirmed the progress made in terms of availability and operation [15,16].

2. Hydrogen storage
Le stockage d´hydrogène

The lack of convenient and cost-effective hydrogen storage is a major hindrance to its widespread use. Improvements in the energy densities of hydrogen storage systems, reductions in cost, and increased compatibility with available and forecasted systems are required before viable hydrogen energy use will be realized. Possible approaches to hydrogen storage include: physical storage via compression or liquefaction, chemical storage such as metal hydrides, and gas-on-solid adsorption. Although each storage method has desirable attributes, no approach currently satisfies all the efficiency, size, weight, cost, and safety requirements for transportation or utility use.
Currently, compressed gas is the only commercially available method for decentralised ambient-temperature hydrogen storage. Tanks may be made from steel alloy, aluminium or carbon/graphite compounds and can be used for either small industrial projects or transportation. Hydrogen is normally compressed to 20 MPa (storage efficiency 1.2 % mass hydrogen per system weight). For storage in cylindrical tanks pressures of up to 30 MPa may be employed, using lightweight pressure vessels. Storage efficiency is approx. 3,1 % mass hydrogen. Systems up to 60 MPa are planned. The main advantages of storing hydrogen as a compressed gas are simplicity, indefinite storage time and no purity limits on hydrogen. In order to reduce the volume required to store a useful amount of hydrogen - particularly for vehicles - liquefaction may be employed. Since hydrogen does not liquefy above 21 K, the process is both time consuming and energy intensive. Up to 40% of the heating value of hydrogen can be lost by liquefying and boil-off losses associated with storage. The advantage of liquid hydrogen is its high energy to mass ratio, which is three times that of gasoline. Large quantities of cryogenic hydrogen are currently used in processes such as petroleum refining and ammonia production. Another notable user is NASA, which has huge 3200 m^3 tanks to ensure a continuous supply for the space programme. The liquid hydrogen will slowly evaporate, and the pressure in the container is usually maintained below 0.3 MPa. If the rate of evaporation exceeds the demand, the tank has to be vented. The emerging small amounts of hydrogen are usually released to the atmosphere. Although liquid hydrogen tanks are usually used to store large quantities of hydrogen, considerable work has gone into the design and development of tanks for cars. BMW developed a 3 cm thick tank with a maximum operating pressure of 0.5 MPa. The tank stores 120 litres (8.5 kg) of cryogenic hydrogen with a storage efficiency of 14.2 % mass hydrogen. Liquid hydrogen tanks have been approved for use in cars in Europe [17,18,19].
Conventional high capacity metal hydrides require high temperatures (300°-350°C) to liberate hydrogen, but sufficient heat is not generally available in fuel cell transportation applications. Certain metals, particularly mixtures of titanium, iron, manganese, nickel, chromium, and others, can react with hydrogen to form a metal hydride in a very easily controlled reversible reaction. Currently existing low temperature hydrides, however, suffer from low gravimetric energy densities and require too much space on board or add significant weight to the vehicle. However, the advantage is the volumetric size. It actually holds more hydrogen per unit volume than pure liquid hydrogen. Manufactured small metal hydride hydrogen containers for portable electronics equipment have a storage efficiency of 0.65 % mass hydrogen. A further major advantage of this method is its safety. Hydrogen is not stored at a significant pressure, and so cannot rapidly and dangerously discharge.
Adsorption of hydrogen molecules on activated carbon has been studied in the past. Although the amount of hydrogen stored can approach the storage density of liquid hydrogen, these systems require low temperatures. Carbon-based hydrogen storage materials that can store significant amounts of hydrogen at room temperature are under investigation. Carbon nanostructures could provide the needed technological breakthrough that makes hydrogen-powered vehicles practical [20]. Other methods are the production of hydrogen by the reaction of calcium hydride or sodium hydride with water. These are very simple methods, but they require disposal of a corrosive mixture of hydroxide and water.

3. Production of hydrogen by means of electrolysis
La production d´hydrogène par électrolyse

Most hydrogen for commercial sale is made in large scale steam methane reformer plants, then liquefied, and shipped by cryogenic tanker and trucks to the customer. There is an existing demand for hydrogen in the chemical and petrochemical industries for the synthesis of chemical raw materials (e.g. production of ammonia, ethylene and methanol), in other cases in the same industry hydrogen is sometimes inevitably produced as a by-product (e.g. through chlorine-alkaline electrolysis for production of chlorine). A second and more important hydrogen producer and consumer is the processing of fuels in refineries (e.g. hydrogen production during thermocracking, hydrogen consumption for desulphurization and hydrogenation of fuels). Various hydrogen production technologies have, to some extent, been tested and used for decades. As a result of this situation, several large scale processes have been developed for the production of hydrogen from fossil fuels and from water. These processes comprise the steam reforming of natural gas, the partial oxidation of hydrogen from heavy fuel oil or coal, chlorine-alkaline electrolysis and finally, the low pressure electrolysis of water [19]. Electricity is presently the only secondary energy carrrier used to produce hydrogen, either by the electrolysis of water or as a by-product resulting from the chlorine-alkaline electrolysis. Of the various procedures for the production of hydrogen from water, electrolysis is presently, and for the foreseeable future, the only one of practical importance. Up to the end of the eighties, only a vanishingly small proportion of approximately 0,1-0,2 % of the world production of hydrogen, was directly generated by electrolysis, mainly in connection with hydro power. This small quantity is even declining since the electrolytic production of hydrogen for fertilizer manufacture is no longer competitive with production from natural gas due to failing energy prices. Because electrolytically produced hydrogen is created indirectly via the energy carrier "electricity", this process is only economically feasible in places where electricity can be extremely inexpensive generated. This is generally only possible with large scale hydro systems (Egypt, Brazil, Iceland, Canada, Norway, Zaire), or with excess energy from the primary and secondary control of existing power station capacity with significant nuclear component (France, Belgium, Switzerland, some German Electric Utilities). There is considerable renewed interest in the use of electrolysis to produce hydrogen as a fuel for automotive applications, with a number of refuelling stations installed around the world. In addition, research continues on the integration of intermittent renewable resources with electrolysers, for producing hydrogen to be used as a fuel or for energy storage [21,22,23].

Tab. I: Potential for electricity generation from renewables in Austria [24]

La capacité de produire de l´electricité à partir d'énergies renouvelables en Autriche

	Theoretical potential	Technical potential
Solar	2200 Mtoe/a	1.7-4.3 Mtoe/a
Wind	7.0 Mtoe/a	0.3 Mtoe/a
Hydropower	10. 0 Mtoe/a	5.1 Mtoe/a

The theoretical potential of electricity production from wind power is estimated with 7.0 Mtoe/a This is based on an ideal converter with theoretical maximum efficiency. Considering technical and economical constraints for wind power technology the technical potential is reduced to 0.3 Mtoe/a (3 TWh/a). Cumulated radiation energy over Austria is approx. 7.9 Gtoe/a (332 EJ/a). This results in a theoretical potential of 2.2 Gtoe/a, considering a maximum conversion efficiency of a Si-cell of 28 %. The technical potential considers available area, and state of the art of commercial technology. The entire roof area of buildings suitable for solar power modules amounts to 107 km^2 with an average annual output of 800 kWh/a, the area of facades (south oriented) 10 km^2 (550 kWh/a) [25], open space (not used for agriculture, etc.) 270 km^2 (900 kWh/a) and noise protection walls 0.14 km^2 (800 kWh/a). This results in a technical potential of 1.7-4.3 Mtoe/a (20-50.2 TWh/a). The theoretical potential of hydropower (complete utilization) amounts to 10 Mtoe/a, the potential worthy of development for hydropower in Austria is approx. 5.1 Mtoe/a (60 TWh/a). The sum of technical potential of solar wind and hydropower amounts to 7.1-9.7 Mtoe/a (83-113,2 TWh/a).

The efficiency of electrolysis is defined by the ratio of Higher Heating Value of produced hydrogen to spend electricity. Advanced electrolysis plants can reach efficiencies of up to 90 %. This results in the production of 266 kg hydrogen or 2958 m^3 of hydrogen out of 1 toe (42 GJ=11.7 MWh) electricity. However, the production of hydrogen from electricity is seen as an option only when it is necessary to transport "renewable" energy over long distances to urban centres or when it is necessary to use hydrogen as a storage medium in providing a continuous supply of electricity from renewable energy sources. Hydrogen as an energy carrier will therefore not compete against electric power but complete it when intermittent renewable resources are used.

Methods for the *direct production* of electrolytically produced hydrogen are under development, i.e. photobiological technology holds great promise but since oxygen is produced along with hydrogen, the technology must overcome the limitation of oxygen sensitivity of the hydrogen-evolving enzyme systems. Certain photosynthetic microbes produce hydrogen in their metabolic activities using light energy. By employing catalysts and engineered systems, hydrogen production efficiency could reach 24%. Unlike cyanobacteria or algae, photosynthetic bacteria do not oxidize water. They do, however, evolve hydrogen from biomass (previously generated from sunlight, water, and carbon dioxide). These bacteria use several different enzymatic mechanisms with near-term commercial potential for biological hydrogen production from biomass. One mechanism in particular looks promising for applications as a biological conditioning agent for upgrading thermally generated fuel gases to a level where they can be directly injected into hydrogen fuel cells. This same system has potential to subsequently evolve into a second-generation photobiological method to produce hydrogen from water [20,26].

4. Hydrogen production from biomass

La production d'hydrogène à partir de la biomasse

The use of biomass represents an indirect means of using solar energy to generate electricity. Compared to biomass hydrogen has the advantages that it is more easily transportable and that it is possible to produce electricity from hydrogen (even in small units) with high efficiency. Presently, no process for hydrogen production from biomass is commercially available. Depending on the method, the processes are in various stages of research and pre-development. The different methods of hydrogen production are: production from solid biomass (e.g. pellets of dedicated energy crops, waste biomass), fermentation of liquid manure and biological hydrogen production. The advantage of direct hydrogen production from biomass is that renewable energy sources can be utilized without the need of electrolysis thus leading to a higher system efficiency and a more favourable overall result.

Hydrogen can be produced by thermochemical gasification of many biomass feedstocks, such as municipal solid waste, agricultural or forest wastes or wood chips from short rotation forestry plantations. The synthesis gas coming from an oxygen-blown gasifier will contain methane and carbon monoxide in addition to the hydrogen. The equipment for converting syngas to hydrogen comprising methane reformers, shift reactors, carbon dioxide removal systems and hydrogen purification are all established technologies in the chemical process industries.

Steam gasification of biomass produces coke, methanol and primary gases in the first stage. This preliminary stage is known as thermal decomposition or pyrolysis. The presence of oxygen in the reactor leads to partial oxidation of the intermediate products rather than reformation. Before the actual gasification, the organic substance breaks up under the application of heat into coke, condensates and gasses. In the second, the reaction with air and/or steam results in a mixture of hydrogen, carbon monoxide, methane, carbon dioxide and nitrogen. Using pure oxygen instead of air or steam for oxidation eliminates the nitrogen component. The transformation of this gas mix into a hydrogen rich gas is named, depending on the feedstock, as gasification (solids) or reforming (gas). Endothermic reactions of the hydrocarbons with steam create synthetic gases with higher hydrogen content, whereby the so called shift reaction can be used to alter the molar carbon monoxide to hydrogen ratio. The hydrogen content of the gas is determined by the process parameters pressure and temperature (compare Tab. III).

Tab. II Potential solid biomass [27]

Le potentiel de biomasse solide

	Theoretical potential [LHV]	Technical potential [LHV]
Biomass	17.1 Mtoe/a	4.3 Mtoe/a

In Austria gasification of biomass offers a great potential for hydrogen production. In the European research project "Solid biomass gasification for fuel cells" various fixed bed reactor types, fluidised bed and circulating bed gasifiers were investigated for the gasification of solid biomass. With the respect to the design of a smaller capacity, the following features are to be considered:

- atmospheric gasifiers are favourable for smaller reactors (<30 MW), especially due to the high cost of the complex feeding system for pressurized gasifiers;
- reactor design and gasification temperature influence the product gas composition, especially the tars, hydrocarbons and the char, high temperature favours the cracking.

The total efficiency of gasification and gas purification depends on the chosen gasifier and gas purification. According to system simulations a total efficiency of 70 % is possible, whereby commercial data for system components were used.

The annual growth of wood in Austrian forests is approx. 32.3 Mm^3 . This results in a theoretical potential of 6.1 Mtoe/a (258 PJ/a). When all arable land is taken for energetic used wood from forests with a short felling cycle it amounts to 9.5 Mtoe/a (400 PJ/a). Together with straw, sewage sludge etc. it amounts to 17.1 Mtoe/a (720 PJ/a). Since only a part can be used energetically, the potential of biomass for energetic usage is estimated with approx. 4.3 Mtoe/a (182 PJ/a). With an efficiency of 70 % for hydrogen production this results to **3.0 Mtoe/a,** that is equal to 8.9 Gm^3 hydrogen.

Tab. III Typical gasifier features [28]
Caractéristiques typiques du gazogène

	Reaction temp. [°C]	**Exit gas temp. [°C]**	**Tars**	**particulates**	**turn-down**	**scalability**	**max size [t/h]**	**Min size [t/h]]**
fixed bed								
downdraft	1000	800	v.low	medium	good	poor	0.5	0.1
updraft	1000	250	v.high	medium	good	good	10*	1
cross current	900	900	v.high	high	fair	poor	1	1.0
fluid bed								
single reactor	850	800	fair	high	good	good	10*	1
fast fluid bed	850	850	low	v.high	good	v.good	20*	2
circulating bed	850	850	low	v.high	good	v.good	20*	2
entrained bed	1000	1000	low	v.high	poor	good	20*	5
twin reactor	800	700	high	fair	fair	good	10*	2
moving bed								
multiple hearth	700	600	high	low	poor	good	5	1
horizontal moving bed	700	600	high	low	fair	fair	5	1
sloping hearth	800	700	low	low	poor	fair	2	0.5
srew/auger kiln	800	700	high	low	fair	fair	2	0.5
other								
rotary kiln	800	800	high	high	poor	fair	10*	2
cyclone reactor	900	900	low	v.high	poor	fair	5	1

** current maxima but capable of scaling up to larger capacities*

5. Conclusion
Conclusion

Hydrogen offers an unparalleled potential for improvements in environmental quality. Possibilities to produce hydrogen out of renewable energy sources in Austria are discussed in this paper whereby solid biomass has the main potential to become a clean source of hydrogen production. The technical potential of hydrogen production in Austria equals to 3.0 Mtoe/a, that is approximately a quarter of the mineral oil consumption of Austria.

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SUMMARY

Hydrogen has the potential to become the future energy carrier for generation of electricity in mobile as well as in stationary applications, and at the same time serving as an energy storage medium for a renewable energy system, to address increasing environmental concerns and energy security. International projects suggest that the biggest drawback for a hydrogen economy - cost competitiveness - could be overcome. The near-term focus as a transition strategy for the production of hydrogen, is steam reforming of abundant, inexpensive natural gas. The resulting cost-competitive hydrogen fuel increases the probability that hydrogen systems will be successfully introduced into many sectors of the economy and become competitive with fossil fuel-based systems following a transition of hydrogen energy production from fossil fuel-based sources to renewable energy-based sources.

The current world-wide interest in a hydrogen economy is spurred by the potential of hydrogen to power non-polluting vehicles. In Austria, energy supply is characterised by the prominent role of renewables and offers therefore the potential for the production of 'clean' hydrogen. The share of renewable energy in the overall energy system has been rising continuously since the mid-seventies and reached the maximum of 26.4 % of total energy supply in 1996. The most important renewable sources of energy are hydropower and biomass. Electricity from hydropower offers a possible path to produce renewable hydrogen, but since the energy relationship between hydrogen and electricity is fixed by physical laws the electrolysis is unlikely to become a predominant method for production of hydrogen. Due to the fact that over the last years only 2/3 of the annual growth of Austrian forests has been harvested, the surplus of wood could be yielded without decreasing the stock on the long-term. The national wood resources offer currently the main potential to be a source for renewable hydrogen in Austria.

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RESUMÉ

L'hydrogène a la capacité de devenir la future source d'énergie pour la production d'électricité dans le domaine des applications mobiles et stationnaires. Il permet également d'être stocké dans un système d'énergie renouvelable afin de venir à bout des problèmes environnementaux et d´assurer l'approvisionnement en énergie. D'après des projets intemationaux, l'inconvénient principal de l´hydrogène, c'est à dire le coût de concurrence de l'économie de l´hydrogène, pourrait être surmonté. L´objectif à court terme et l´etape transitoire de la production de l´hydrogène, est le reformage à la vapeur du gaz naturel abondant et peu coûteux. L´hydrogène rentable qui en résulte permettra très probablement aux systèmes de l´hydrogène d'être introduits avec succès dans un grand nombre de secteurs économiques et de faire concurrence aux systèmes à base de combustibles fossiles. D'ailleurs l´hydrogène ne sera plus produit au moyen de sources d'énergie à base de combustibles fossiles mais à base d´énergies renouvelables.

L'intérêt mondial actuel de l'économie de l´hydrogène est motivé par la capacité de l´hydrogène à alimenter des véhicules non polluants. En Autriche, les énergies renouvelables représentent une grande part de l'approvisionnement en énergie et permettent de produire l´hydrogène 'propre'. La part de l'énergie renouvelable au système d´énergie total a continuellement augmenté depuis le milieu des années soixante-dix pour atteindre un taux maximale de 26,4 % de l'approvisionnement total en énergie en 1996. Les principales sources d'énergies renouvelables sont l´hydraulique et la biomasse. L'électricité provenant de l'énergie hydraulique ouvre une nouvelle possibilité de production de l'hydrogène renouvelable. Etant donné le rapport énergétique entre l´hydrogène et l'éctricité déterminé par les lois physiques, il est peu probable que l'électrolyse devienne une méthode prédominante pour la production de l´hydrogène. Alors que seulement 2/3 de la croissance annuelle des forêts autrichiennes ont été abattues ces dernières années, l'excédent de bois pourrait être utilisé sans affecter le stock à long terme. Les ressources nationales de bois offrent actuellement la plus grande capacité de source d'énergie renouvelable qui pourrait être utilisée pour la production de l´hydrogène en Autriche.