Hydrogen Energy
A Comprehensive Approach Integrating Energy Systems for Sustainable Development

Complementary to

Sahara Wind

Energy Development Project
-Phase 1-

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International Seminar on the Hydrogen Economy for Sustainable Development

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'Trends to 2030' report of the European Commission Transport and Energy
Previsions of installed electric generating capacities in Europe

Power generation capacity by type of plant in EU-25, 1995-2030.

	GWe					%Share	
	1995	**2000**	**2010**	**2020**	**2030**	**2000**	**2030**
Nuclear	134.7	140.3	129.8	108.0	107.8	21.4	9.5
Large Hydro (pumping excl.)	91.0	93.9	95.8	96.3	97.0	14.3	8.6
Small Hydro	2.0	2.1	8.1	12.2	14.5	0.3	1.3
Wind	2.5	12.8	73.5	104.7	135.0	2.0	11.9
Other renewables	0.0	0.2	0.5	0.7	14.3	0.0	1.3
Thermal plants	381.4	406.1	484.8	639.0	762.9	62.0	67.4
of which cogeneration plants	80.7	93.2	117.6	150.9	179.5	14.2	15.9
Open cycle - Fossil fuel	339.4	335.2	278.9	210.0	196.8	51.1	17.4
Clean Coal and Lignite	0.0	0.0	0.0	0.8	5.5	0.0	0.5
Supercritical Polyvalent	0.0	0.0	0.8	55.3	126.3	0.0	11.2
Gas Turbines Combined Cycle	20.0	47.3	173.3	313.8	367.4	7.2	32.5
Small Gas Turbines	21.2	22.7	30.6	57.8	65.5	3.5	5.8
Fuel Cells	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geothermal	0.7	1.0	1.2	1.3	1.4	0.2	0.1
Total	**612**	**655**	**793**	**961**	**1132**	**100**	**100**
current EU	539	579	689	813	951	88	84
acceding countries	73	77	104	148	181	12	16

Source: PRIMES, ACE.

Sahara Wind Energy Development Project

Energy Access

The Trade Winds blowing along the Atlantic coast from Morocco through Senegal represent the largest, most productive wind energy potentials available on earth.

Because of its erratic nature, wind energy cannot be integrated locally on any significant scale unless far ranging, more advanced energy technologies are considered.

Wind Energy is the fastest growing, most competitive renewable energy, but intermittency and grid stability issues* limits the extent to which such energy can be used.
(*power margins, dispatching, reactive compensation, voltage, frequency regulation, flickers, harmonics…)

- **Denmark: Wind energy only 20% of electricity consumption despite good wind speeds, high energy prices and a sophisticated, highly interconnected grid. No new capacity added since 2005.**

Germany: Europe's most powerful grid (120.000 MW) encounters similar problems in integrating & stabilizing only 7% of its electricity consumption through wind energy.

Problems are more acute in weaker grid conditions

(handling wind energy fluxes with no interconnection possibilities)

Mauritania 120 MW, Senegal 239 MW, Niger 105 MW, Mali 280 MW, Chad 30 MW

These Countries have area 2-3 times the size of France / Iceland (1500 MW) pop. 290,000.

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Wind Energy and Capacity Building

Small window of opportunity for integrating a sustainable energy economy locally **HOWEVER:**

- **Industrialized countries export turnkey projects instead of transferring technology.**
- **Small grid absorption capacities 'politically' split to please as many donor countries as possible.**

Case Study: Egypt's Zafarana turnkey wind project (Sponsor Countries)

•1998-2003	60 MW Danish (Aid/Export credit)
•2002-2004	80 MW German (Aid/Export Credit)
•2005-2006	85 MW Spanish (Aid/Export Credit)
•2006-2007	120 MW Japanese (Aid/Export credit) …& others
1998-2007	345 MW+

As a result, no strategy can be developed for integrating Wind/RE technologies.
Potential risks of such approach: grid will soon saturate to further Wind developments.

Should other African countries follow the same model?
Mauritania 120 MW, Senegal 239 MW, Niger 105 MW, Mali 280 MW, Chad 30 MW

Hydrogen economy is just the opposite approach: **Needs to be Comprehensive & Integrated**

- **Holistic approach**
- **Broad ranging, integrated process**
- **Bottom-up capacity building**
- **Capitalizing on available human resources & research institutions**
- **Creates research networks sensitized on issue**
- **Fosters regional collaborations & prevents energy technology gaps from widening**
- **Countries with large RE potentials & limited energy more accessible to H2 technologies**

It may be sensible to start there…and make a case for a Carbon-free Hydrogen Economy

Sahara wind

UNIDO/ICHET - Sahara Wind-H_2 Demo Project

UNDP/GEF - Sahara Wind Project Phase 1: 400-500 MW / Extensions HVDC (5 GW)

GEF

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Electricity High Voltage Line technologies

High Voltage Direct Current (HVDC) *versus* High Voltage Alternating Current (HVAC)

Left: 3,000 MW HVDC (Pacific DC Intertie, PDCI) **Right: 300 MW HVAC**

Near Bishop, California USA

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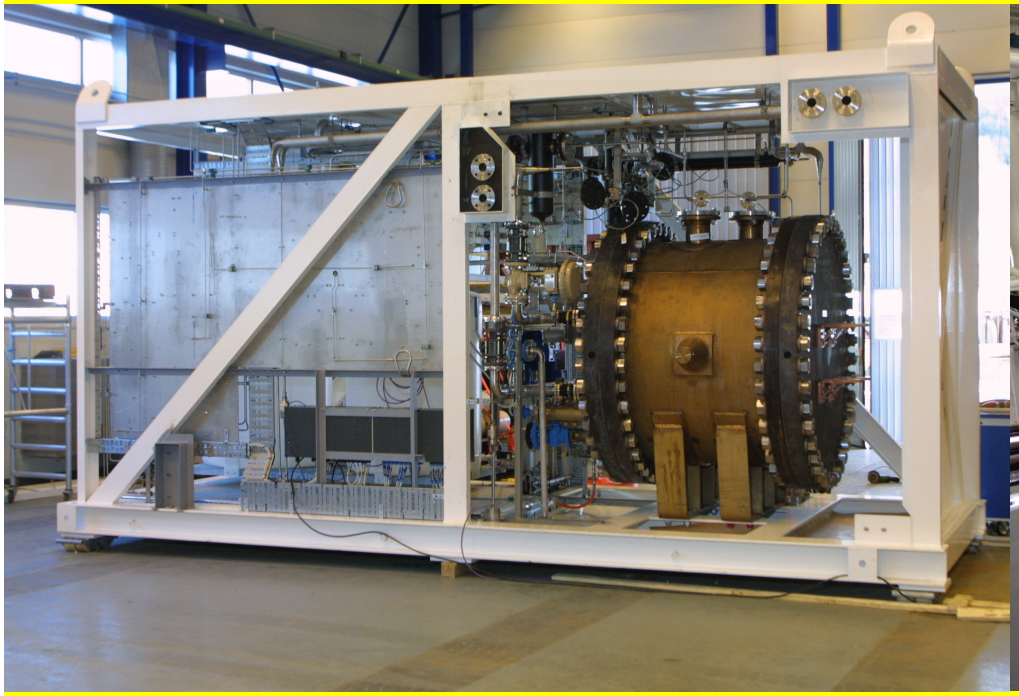
Wind-Hydrogen Electrolysers types (Pressurized)

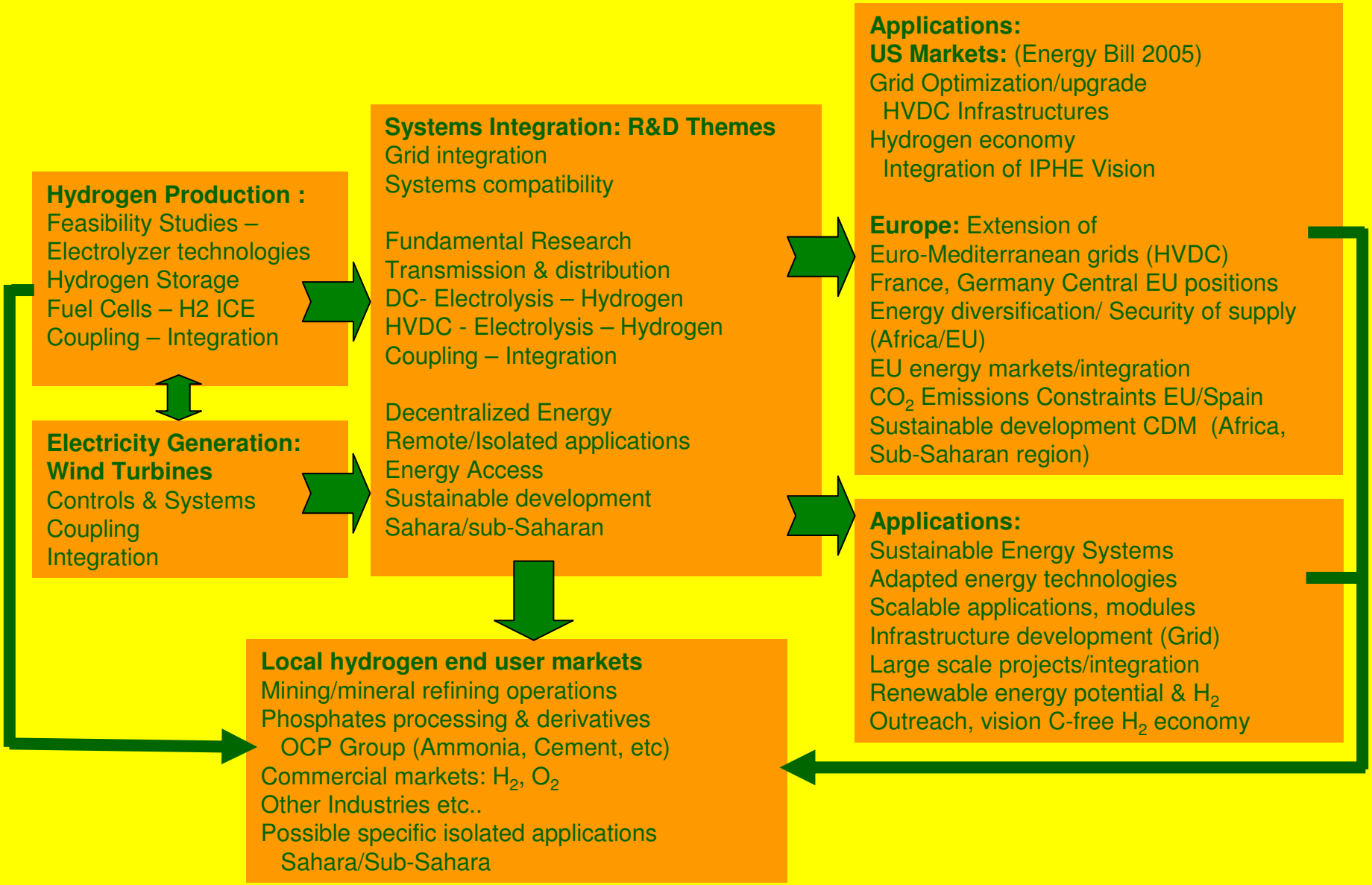


Norsk Hydro electrolyzer, KOH type 560 kW
130 Nm3 / hour at 450 psi (30 bar)
Photo: Norsk Hydro Electrolysers

Norsk Hydro Electrolyzers 2 MW each

Sahara Wind-H_2 Electrolysis Demo/Pilot Project

Integrated Sustainable Energy solutions
in Tarfaya, Morocco



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Hydrogen and capacity Building

The introduction of hydrogen energy technologies at an early stage, through regional applied research projects will establish and identify areas where potential breakthroughs can become significant in the future.

Hydrogen as an energy carrier to store intermittent sources of energy is scalable and can be worked into modules, small medium, large integrated applications.

Involving domestic scientific communities will enable newer, wide-ranging approaches to better integrate the region's real renewable energy potentials.

The region disposes of a qualified pool of University Professors, Engineers and Scientists that currently lack appropriate Research Infrastructures.

Equipping and networking the main research institutions in Morocco and Mauritania with the financing of Wind/Hydrogen/fuel cell test benches, is a first step towards a successful, gradual introduction of state-of-the-art energy technologies.

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Wind Energy & Hydrogen Economy

University / Research institutions are ideally suited to integrate new energy technologies as Commercial Wind Energy ventures are hardly profitable in Sub-Sahara Africa due to limited size of electricity markets and grid infrastructures.

Besides testing and disseminating technology, applied research centers could feed into the grid boosting local electric generation capacities, (electricity sales could support H_2 research activities).

Applied research on hydrogen technologies could enable a significant uptake of intermittent sources of wind energy in decentralized applications paving the way to future large scale Wind/HVDC transfer infrastructures.

Wind-Hydrogen electrolysis utilizing regional electricity market opportunities is an ideal testing ground for applying the latest research and technological breakthroughs in the development of a renewable driven hydrogen economy.

Local Hydrogen end user market: Non-Energy
Morocco's Phosphate Industry (World's largest exporter) could use Hydrogen to produce Ammonia, phosphoric acid and Clean Portland Cement (without CO_2 emissions) when recycling Phosphor-gypsum currently being dumped into the Ocean (12 Mtons/yr).

NATO Workshops on Security Related Issues:
Hydrogen, Energy Security, Energy Access

The African Continent's energy challenges are part of a broader economic context pertaining to energy access, sustainability and in many cases energy resource limitations...

Morocco has a 96% energy dependency from fossil fuel imports absorbing most of the Country's export revenues.

The case is very similar with many sub-Saharan Countries that lack critical energy supplies to cover their most basic needs.

1.6 Billion people do not have access to electricity worldwide and in alarming proportions in Africa, this situation is simply not acceptable… nor accepted!

Fluxes of (Illegal) Immigrants from Sub-Saharan Africans to Europe have become a security threat to the entire region.

A Security response is limited and cannot be considered a long term solution

Fixing Migrant Populations remains a critical task

Limited energy access, energy dependencies (oil imports higher then foreign AID), combined to land degradation, desertification and demographic pressure on largely agricultural based societies tend to generate economic distress…

NATO Advanced Research Workshop
Security Related Issues: Illegal Immigration

‘Cayucos’ Boats carrying illegal immigrants off the Canaries Islands

At least 1,600 immigrants drowned since January 2006 (Red Cross estimates).

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Hydrogen Energy Development Activities

On a more positive note, development activities described are essential for evaluating the possible utilization of hydrogen technologies to enhance the uptake of renewable energy in the weak grids infrastructures of the region.

The Sahara Wind-Hydrogen demo/pilot projects is likely to be included into the International Partnership for the Hydrogen Economy's future list of collaborative projects involving several IPHE member countries, these activities could also bridge hydrogen production technologies with the needs of different countries, particularly developing countries.

Finally, the objective of our project is to build capacity and enable applied research to be conducted on hydrogen energy technologies in both Morocco and Mauritania, and stimulate wider regional cooperation to support large scale production of carbon free hydrogen from wind-electrolysis on an unprecedented scale.

Aerial picture of coastline North of Tarfaya

Aerial picture of dry river (Oued) estuary North of Tarfaya

Sparse vegetation around Tarfaya (Atriplex)

Inert Rocks in plains around Tarfaya

Sahara wind

225 kV public ONE grid line heading North, 20 km away from Tarfaya

more information available at:
www.saharawind.com

GEF

UNIDO