Wind Energy and Hydrogen: combined experiences in Pico Truncado Experimental H2 Plant in Argentine Patagonia

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Río Gallegos- Argentina

Hydrogen + Fuel Cells 2013
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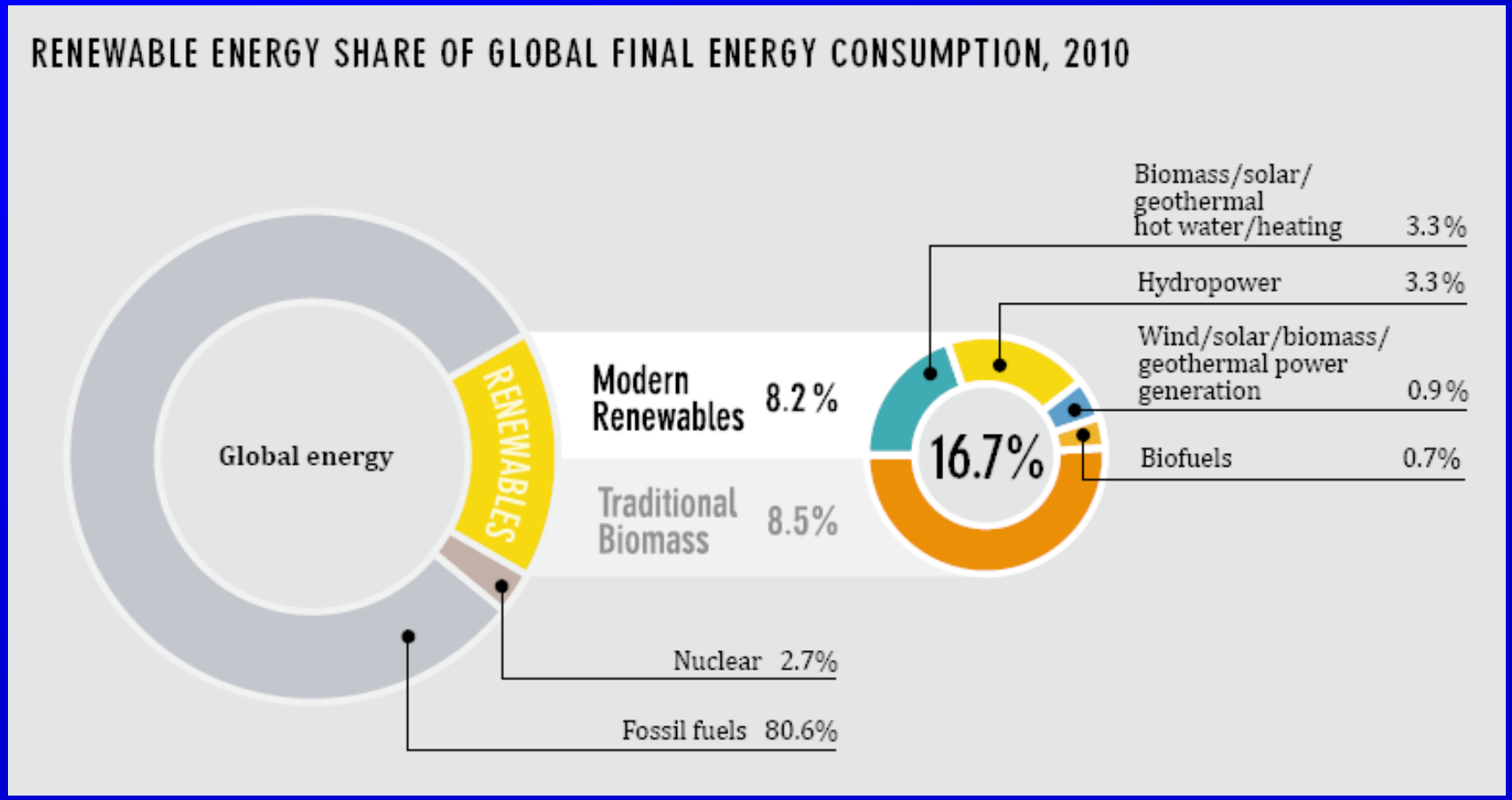
Contents

- Facts – global use of energy and hydrogen, use in Argentina and Patagonia.
- Wind Energy use – Resource measurements, wind parks and grid extension in Patagonia.
- The Pico Truncado Experimental Hydrogen Plant
- Isolated hybrid power systems
- Conclusions and Future Perspectives.

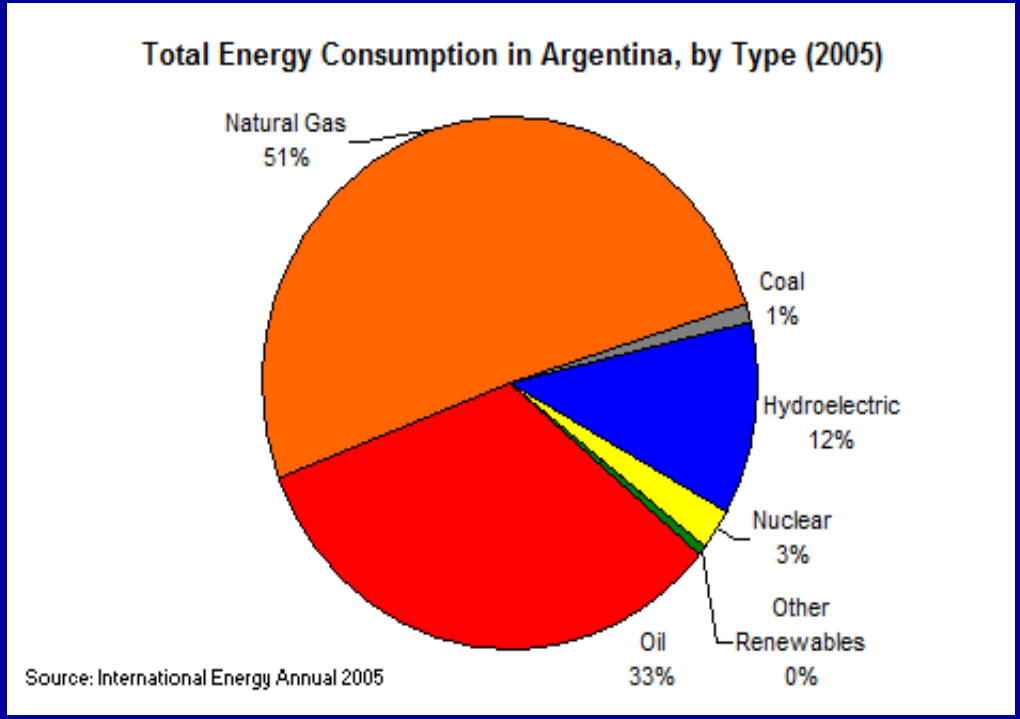
Renewable Fraction of Global Primary Energy used (2010)



(Source: Renewable Energy Status Report 2012)

Argentina: Facts and Primary Energy Use

- Population:
  - 40.7 million (estim.)
  - Urban population 87%
- *GDP* per capita *(PPP)*:
  - 2012 – u$s18,112 (IMF)
- Primary Energy Use by source:



Argentina (2005)
Source: EIA, 2007

Electric Power in Argentina

Electric Power Sector:

1. Generation: from 82.9TWh (2001) grew to 135TWh (2011). Typically 65% thermal, 30% hydro, 5% nuclear & other

2. End-user electrification : (Estimated) 95% en 2010

3. Losses in transmission/distribution : 11.88%(2005)

4. Level of generation by natural gas/combined-cycle: reached 31% in 2001, still in expansion.

Source: EIA Reports and Energy Secretary at: http://energia3.mecon.gov.ar

Installed Power for Electrical Generation by region and source in Argentina (MEM – 04/2013)

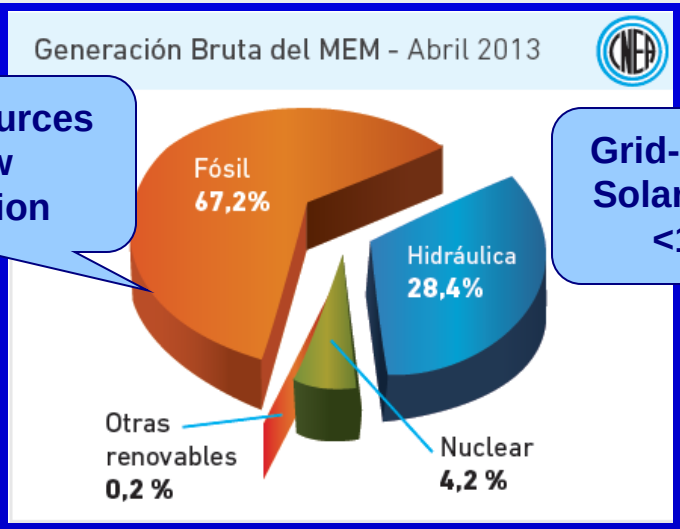
Area	TV	TG	CC	DI	TER	NUC	SOL	EOL	HID	TOTAL
CUYO	120,0	89,6	374,2		583,8		6,2		1069,7	1659,7
COM		207,9	1282,5	73,3	1563,7				4680,7	6244,4
NOA	301,0	1001,0	829,2	259,9	2391,1		2,0	25,2	217 ,2	2635,5
CENTRO	200,0	510,8	547,3	63,5	1321,6	648,0			917,6	2887,2
GB-LI-BA	3820,2	2045,5	5984,0	398,6	12248,3	357,0		0,3	945,0	13550,6
NEA		59,0		242,3	301,3				2745,0	3046,3
PAT		160,0	188,1		348,1			86,3	518,8	953,2
GENERACIÓN MÓVIL				220,0	220,0					220,0
SIN	4441,2	4073,8	9205,3	1257,6	18977,9	1005,0	8,2	111,8	11094,0	31196,9
Porcentaje					60,83	3,22	0,03	0,36	35,56	

[In MW]

http://www.cnea.gob.ar/comunicacion/publicaciones.php

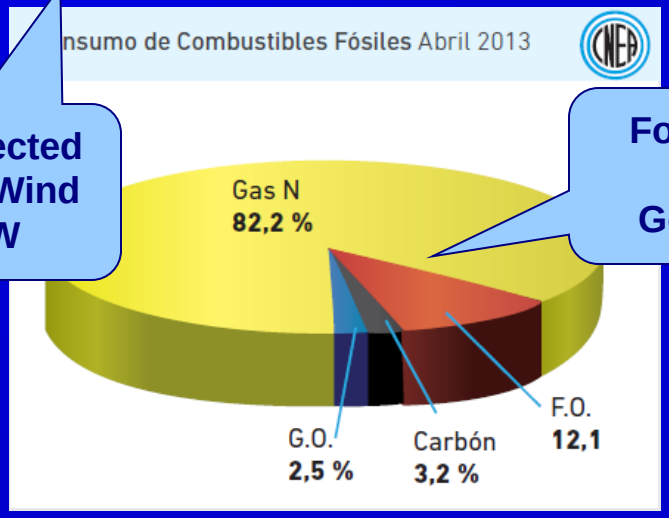
Source: Comisión Nac. De Energía Atómica – Report MEM 04/2013

Energy Sources of Raw Generation



Grid-connected Solar and Wind <120MW

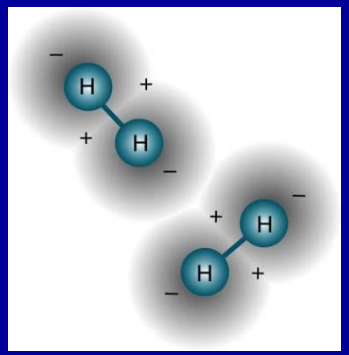
Fossil Fuels used in Generation



Hydrogen

HYDROGEN (H) is...

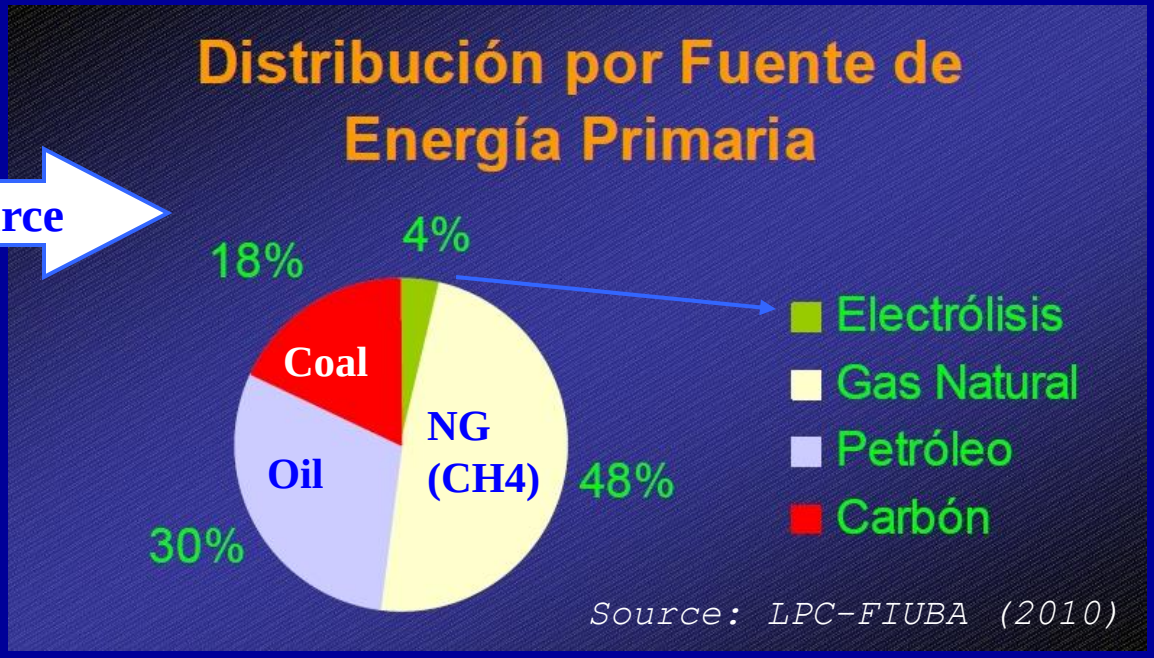
- The most simple and abundant chemical element.
- The lightest of all gases (0.08432 mg/cm^3)
- Not free in nature, its production requires energy.
- Usable as an energy vector.

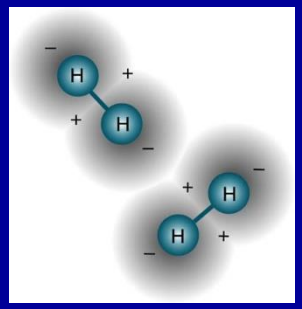


Hydrogen

- Hydrogen is globally used in many chemical and industrial applications, with mature production and transportation technologies.
- H production:

By energy source

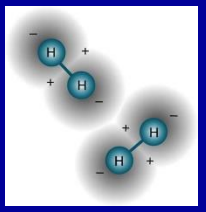




"Captive": About 95% of H produced is consumed on-site

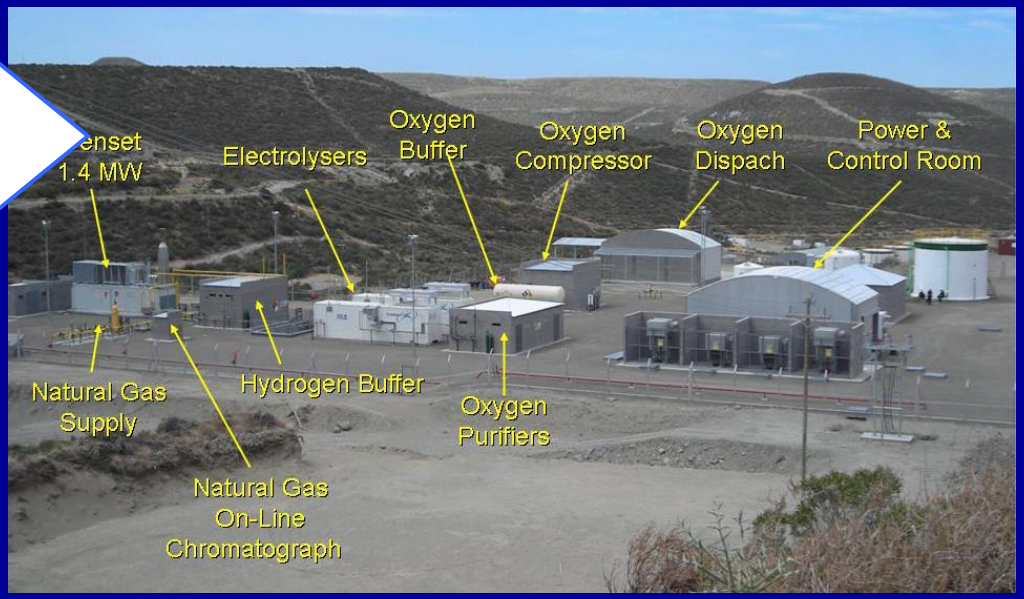
Hydrogen in Argentina

- Main Hydrogen production in fertilizer (urea, NH3) industry (>10^6 ton/yr, 50% share), military, methanol (>475*10^3 ton/yr), Jet Fuel and special gases.
- Mostly from steam reforming of CH4, but notable exceptions are:



1) CAPSA/CAPEX Diadema Plant, 2 x 325kW electrolysers (2009) Added 6.3MW windpower in 2011

2) Pico Truncado H2 plant (2005), 2.4MW windpower, In process of adding 1 x 500kW AccaGen - Electrolyser



Source: WHEC2010 Clean Hydrogen Production in Patagonia Argentina
S. Raballo, J. Llera, A. Pérez, J. C. Bolcich

Hydrogen and Renewable Energy

Fuel cells can convert pure H2 to electric power with efficiencies > 50%

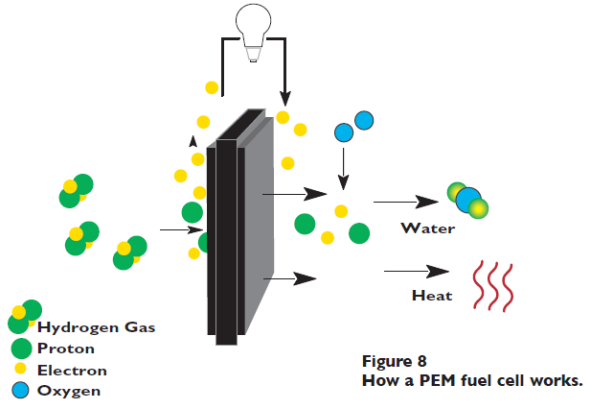
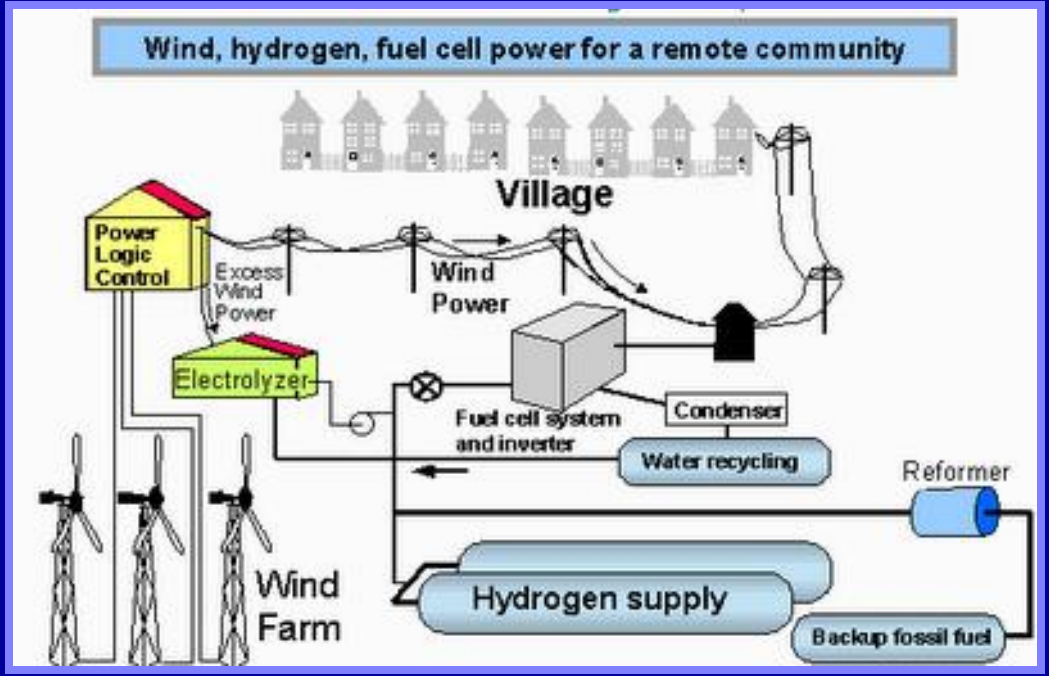
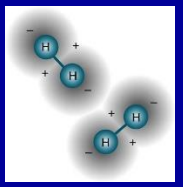


Figure 8
How a PEM fuel cell works.

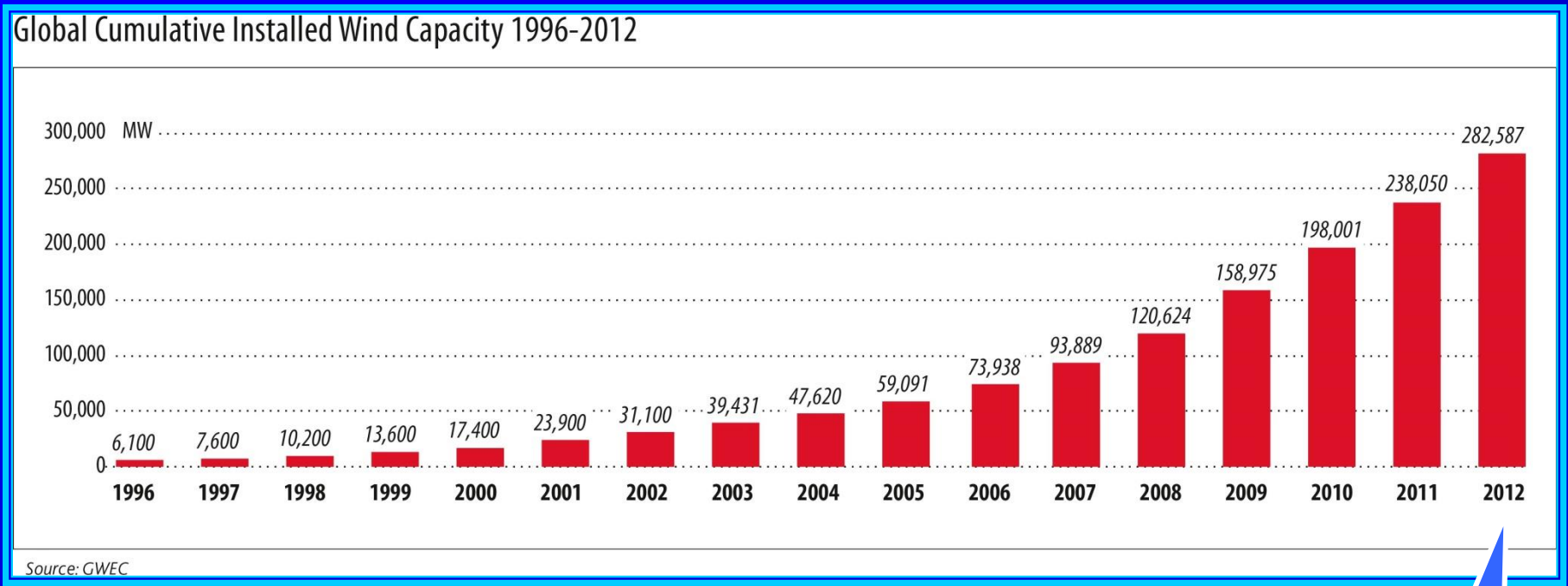


Source: Third Orbit Power Systems, Reno NV

- Hydrogen for energy use could be produced by electrolysis competively if renewables managed to supply very cheap electric power, and storage issues for H_2 are solved.



WORLD GRID-CONNECTED WIND CAPACITY (2012)

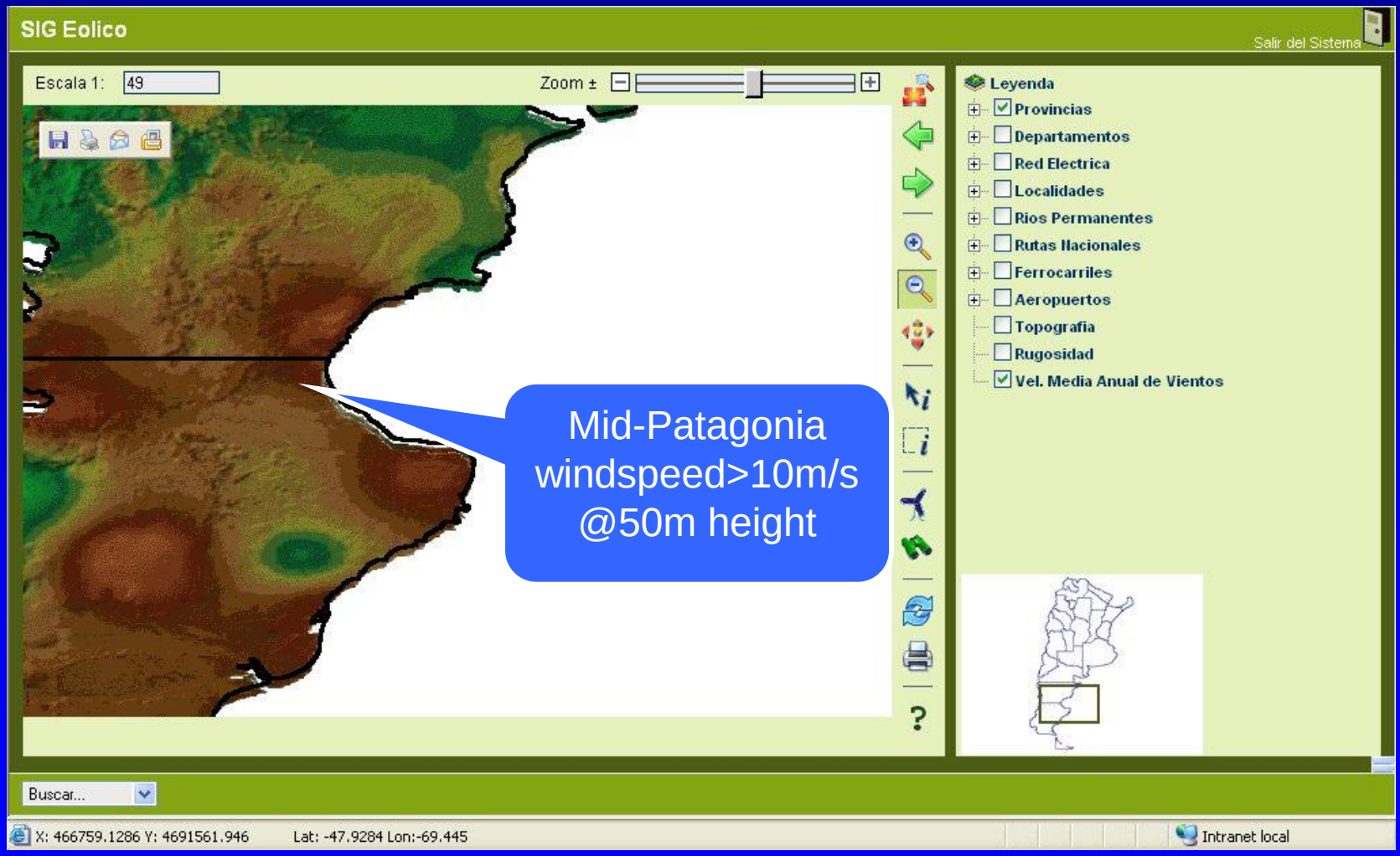


Conventional Wind Turbine technology depends on grid availability and external generators to keep grid operating. Injects active power with no storage possibilities. Technology is mature and installation prices (<2*10^6 usd/MW) continue to drop.

282.5 GW – end 2012

Wind resource

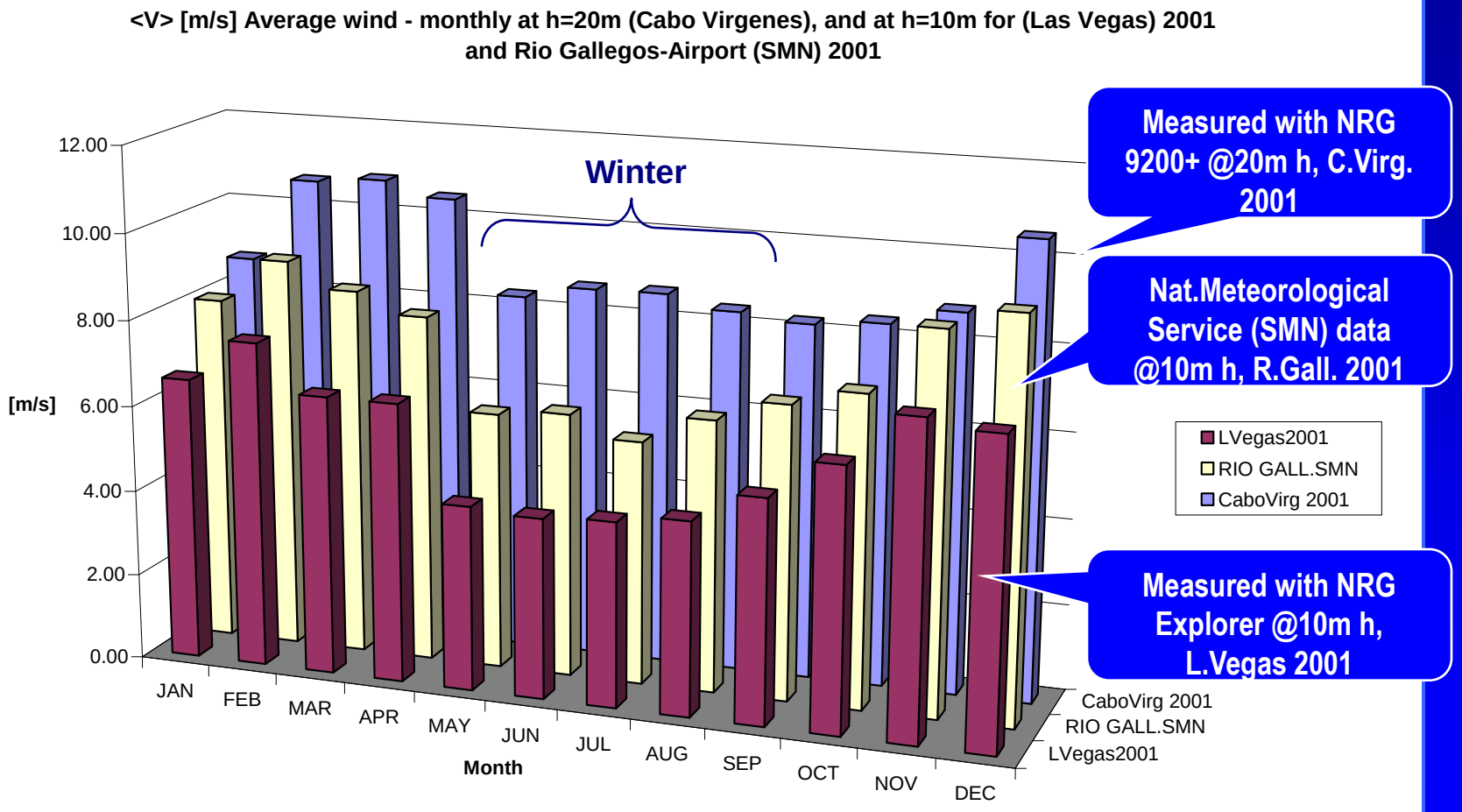
Wind-GIS by CREE (Centro Regional de Energía Eólica)



Wind - GIS (*Geographical Information System*) developed by CREE (Centro Regional de Energía Eólica) in Rawson, Chubut - developed by Dr. Hector Mattio & team

Wind Resource

Comparing measurements in South Patagonia



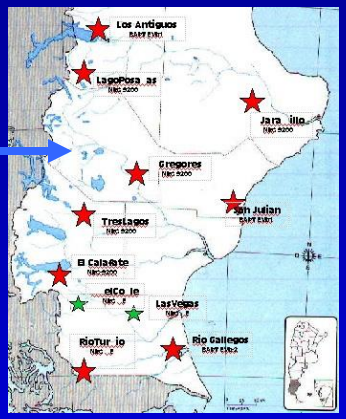
Compared measurements of wind intensity in South of Santa Cruz (Rio Gallegos, Las Vegas, Cabo Vírgenes) during 2001

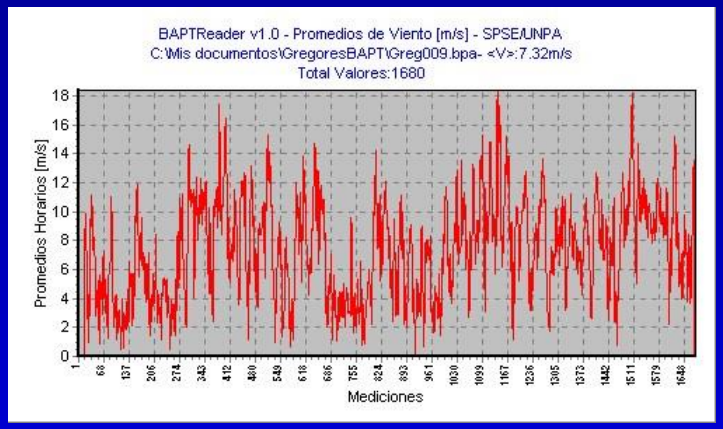
Wind Resource

Measurement network in Santa Cruz (UNPA-SPSE)

Measurement sites with BAPT and NRG automatic stations

(1997-2005)





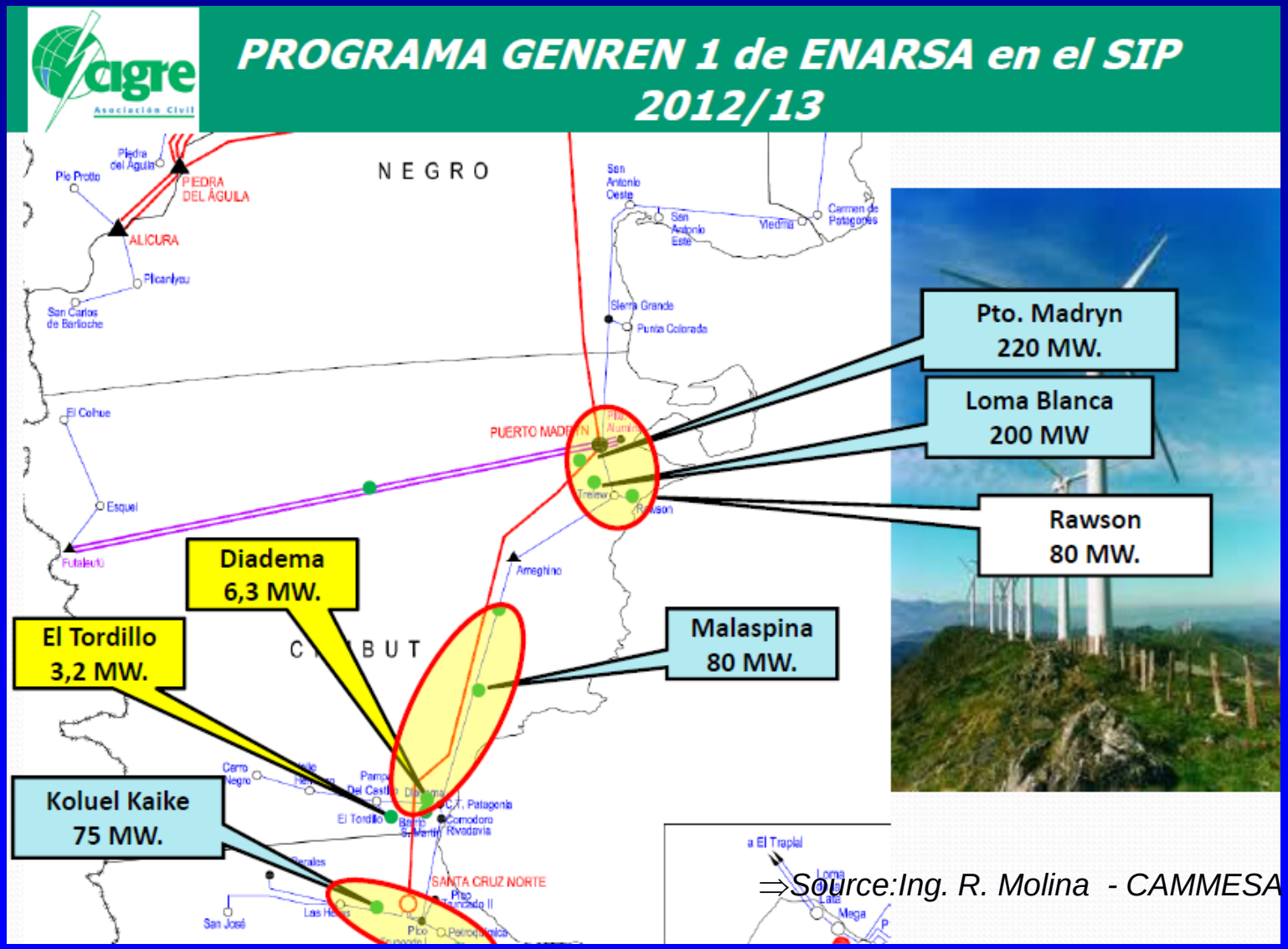
BAPT EVD1 - San Julián

NRG9200+ LagoPosadas

NRG9200+ Gob.Gregores

Wind resource measurement network in Santa Cruz by agreement UNPA/SPSE

Wind parks & grid extension in Patagonia / GENREN program

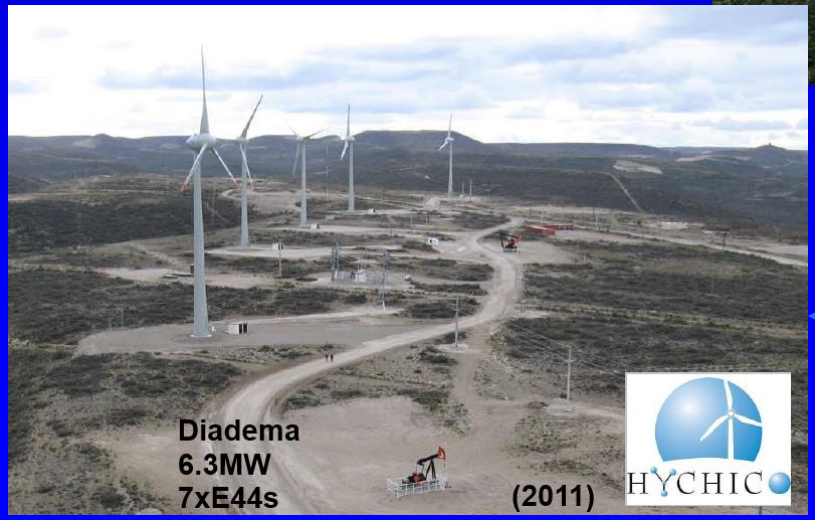


⇒Source:Ing. R. Molina - CAMMESA

Wind parks & grid extension in Patagonia / recent additions

RAWSON Emgasud Windpark
43x VESTAS 1.8MW V90s (2011/12)
GENREN I Program Financing

ENARSA / El Tordillo
IMPSA 1.5MW (2010)
PMSG+FullConverter
Class I+



HYCHICO Windpark (inst.2011),
7x Enercon 0.9MW E44s coupled
with CAPSA/CAPEX Diadema Plant,
2 x 325kW electrolysers (2009)

JORGE ROMANUTTI WIND PARK (2.4MW) IN PICO TRUNCADO

4 X ENERCON/WOBBEN E40-600kW (2001-5)

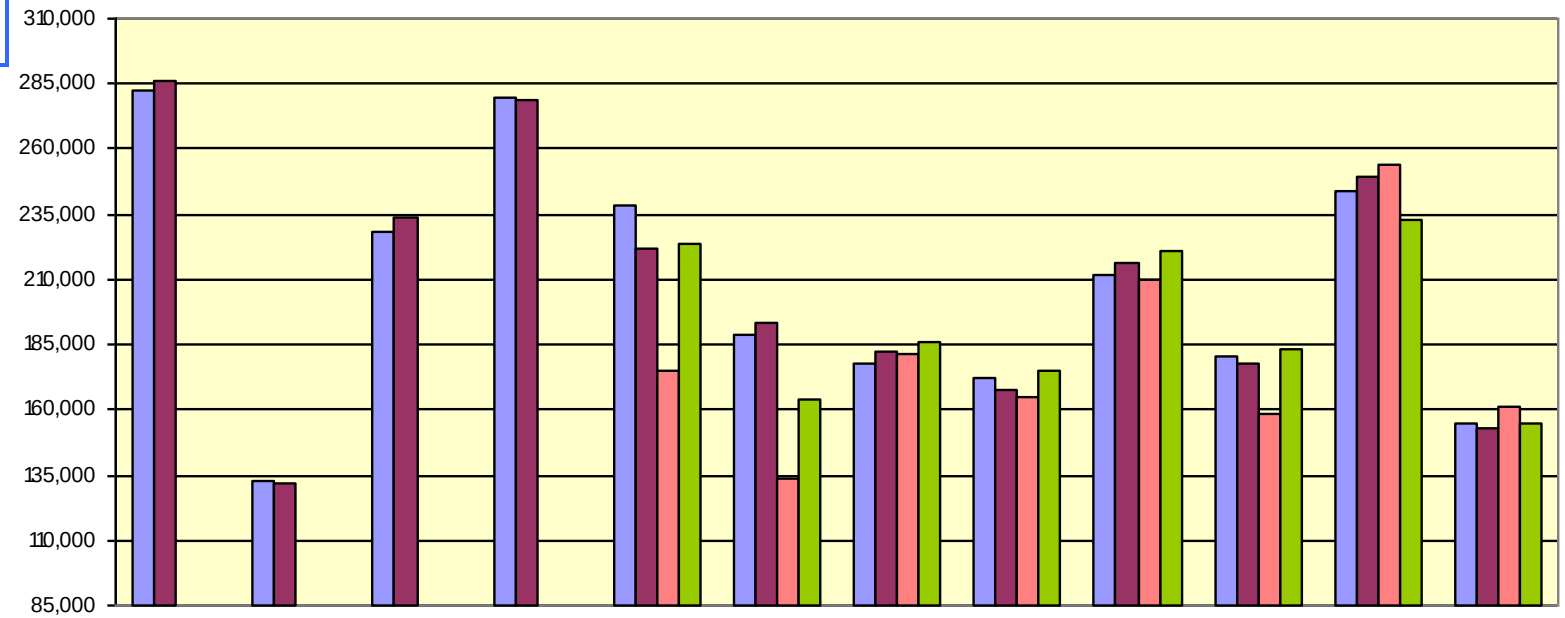
Avg. Wind speed @ 40m height = 9m/s

Nominal Power = 2400kW

17

Production of Enercon E40 WTGs in Jorge Romanutti Windpark – Pico Truncado

Avg. 2004
E40 Park
CF:49.5%



	ene-05	feb-05	mar-05	abr-05	may-05	jun-05	jul-05	ago-05	sep-05	oct-05	nov-05	dic-05
AERO 1	282,047	132,923	227,900	279,284	238,063	188,319	177,962	172,058	211,390	180,202	243,560	155,194
AERO 2	286,447	131,515	233,869	278,364	222,265	193,287	181,993	167,841	216,388	177,521	249,082	152,662
AERO 3					174,958	134,131	181,113	165,194	209,733	158,778	254,391	161,105
AERO 4					223,854	164,360	185,774	175,187	221,209	183,327	232,983	154,807

The Pico Truncado Experimental Hydrogen Plant + Windpark

Projected by Asociación Argentina del Hidrógeno (AAH) and the Pico Truncado Municipality from 2002 (design), 2003-2004 (construction) and commissioning (2005)

Director: Dr. Juan Carlos Bolcich (CNEA/AAH)

The Pico Truncado Experimental Hydrogen Plant + Windpark

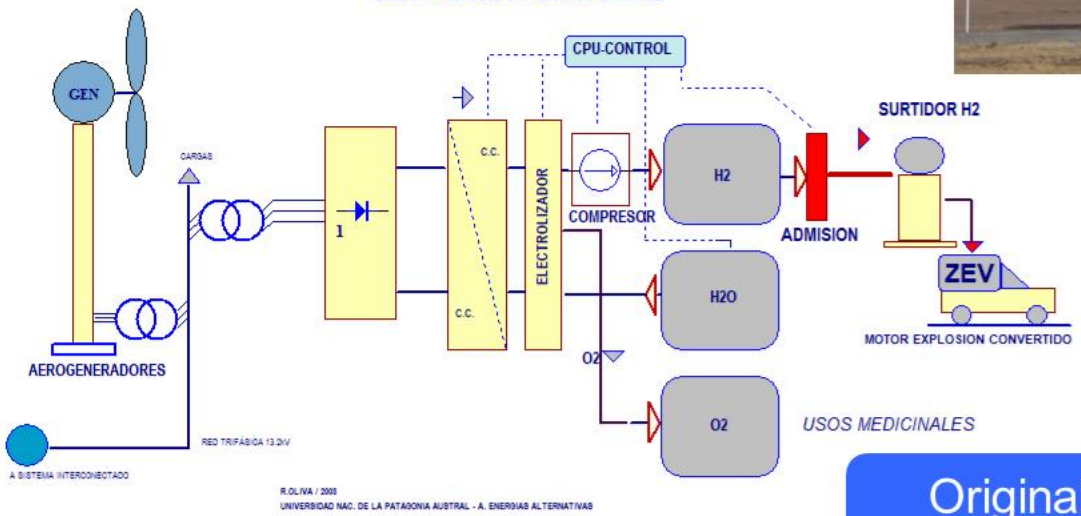
Construction phase 2004

SISTEMA EOLICO A RED CON ELECTROLIZADOR Y TA

PRODUCCIÓN DE HIDRÓGENO PARA TRACCION

MUNICIPALIDAD DE PICO TRUNCADO - ASOCIACIÓN ARGENTINA DEL HID

DIAGRAMA FUNCIONAL



Original Stuart 5kW electrolyser

Experimental Hydrogen Wind-Electrolyzer Plant in Pico Truncado

H2-Compressor & Storage Tanks

Stuart 5kW Electrolyzer & ITBA 6kW Electrolyzer
- Production of Hydrogen from Wind-fed grid.
- Experimental and research facilities
- Uses: modified internal explosion vehicles and small fuel-cells

Experimental Hydrogen Wind-Electrolyzer Plant in Pico Truncado

Strong commitment to education and technology practice in laboratories: PT H2 Plant regularly organizes courses on Hydrogen and related subjects

Hydride Storage

Laboratory and fuel cell practices

Experimental Hydrogen Wind-Electrolyzer Plant in Pico Truncado

Internal combustion engines modified for use with H2 gas (200bar) and H2 + CH4 mixtures

Experimental Hydrogen Wind-Electrolyzer Plant in Pico Truncado

PLANTA EXPERIMENTAL DE HIDROGENO
Pico Truncado - SANTA CRUZ - Patagonia Argentina

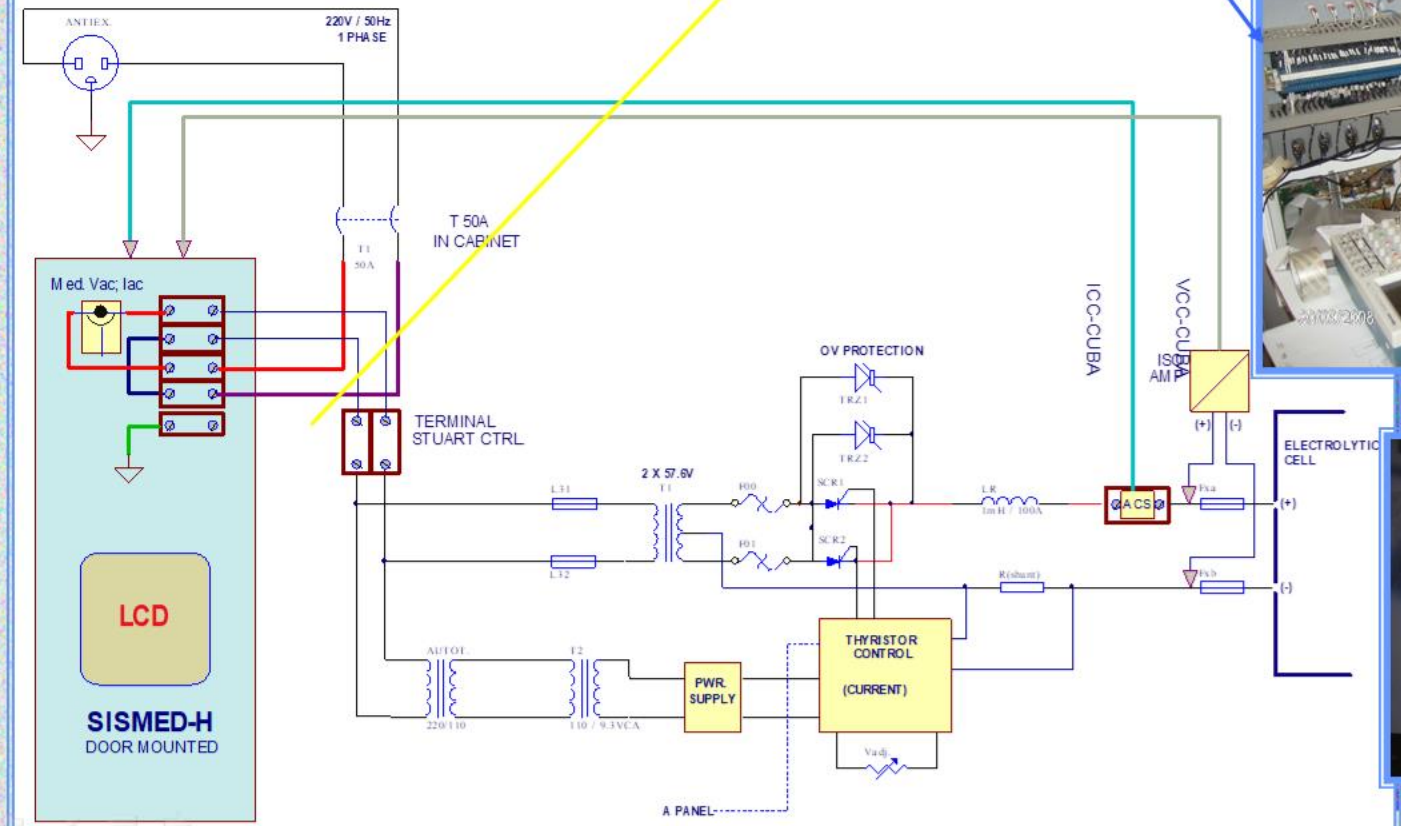
UNPA

SISMED-H Monitoring system for original Stuart 5kW electrolyzer (UNPA)

STUART ELECTROLYZER - 5kW

RECTIFIER + SENSOR DIAGRAM

PLANTA H2 PICO TRUNCADO -1ST rev7- 10-08/ 2ND 05/2013- INGR OLIVA



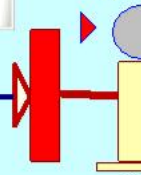
Experimental Hydrogen Wind-Electrolyzer Plant in Pico Truncado -Expansion

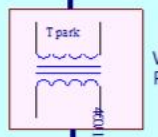
2011-2012 Plant enters semi-industrial phase with acquisition of 500kW Acca-Gen Advanced "ZeroPressurStack" technology
Up to 100Nm³ / h of H2, 50Nm³ / h of O2

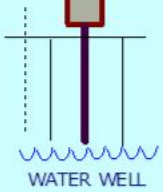
ACCA-GEN ELECTROLYZER - 500kW

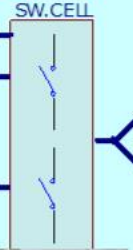
BLOCK INSTALLATION DIAGRAM

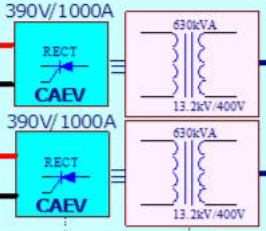
PLANTA H2 PICO TRUNCADO 05/2013-- ING.R.OLIVA

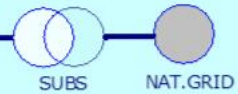






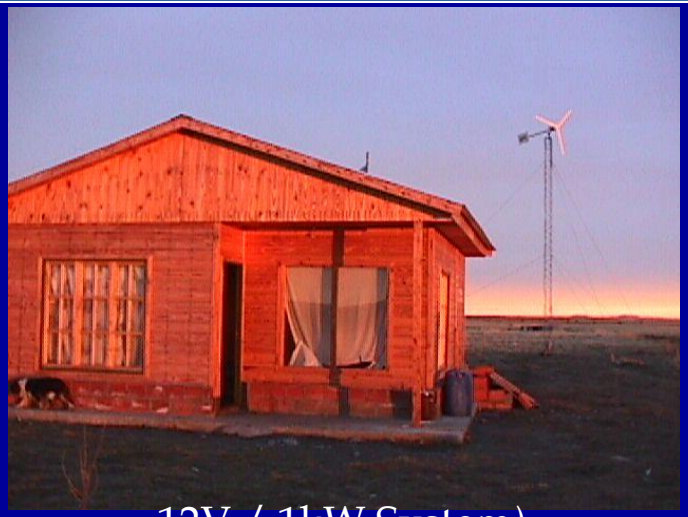






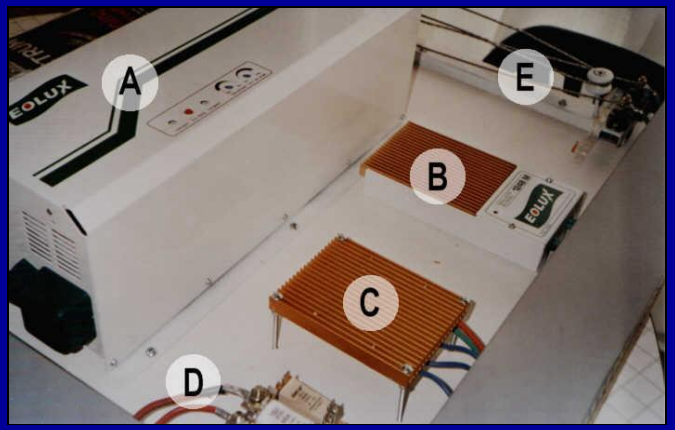
Small Isolated Power Systems in Patagonia – Potential for H2 applications

2kW/48V system in Rio Gallegos



12V / 1kW System)

Internals: Batteries, regulator, inverter



Small Isolated Power Systems in Patagonia – AAH/ITBA's MAEL testing in Antarctica

5kW Wind turbine, 6kW Electrolyser, H2 Storage

Small Isolated Power Systems in Patagonia – Potential for H2 applications

Wind/PV Oil Industry supply for low power chemical injection / remote well

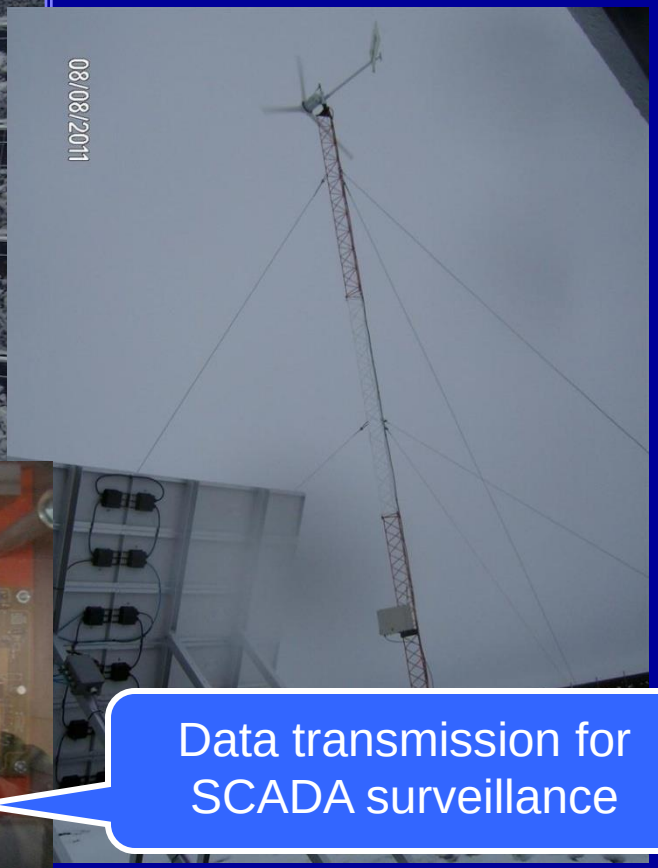
Small Isolated Power Systems in Patagonia – Potential for H2 applications

PLANTA EXPERIMENTAL DE HIDROGENO
Pico Truncado - SANTA CRUZ - Patagonia Argentina

UNPA
Universidad Nacional de la Patagonia Austral

DM Energias Renovables

Winter maintenance



Data transmission for SCADA surveillance

Conclusions and future perspectives

- An enormous potential exists for the development of wind energy in South Patagonia - Argentina, and its combination with hydrogen technologies
- At the Pico Truncado Experimental H2 Plant, focus is on education, local development and adaptation of technologies.
- Support for further development and legal incentives for H2 and wind must be found.

Acknowledgements

Special thanks to Dr. Juan Carlos Bolcich (AAH), the Canadian Hydrogen and Fuel Cell Association, Universidad Nacional de la Patagonia Austral, Municipalidad de Pico Truncado, SPSE

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(Energias Alternativas)