Electrolytic Hydrogen Production Workshop, National Renewable Energy Laboratory, Golden, Colorado, Feb 27-28, 2014

Current Initiatives for Electrolytic H_2 Production at HySA Infrastructure

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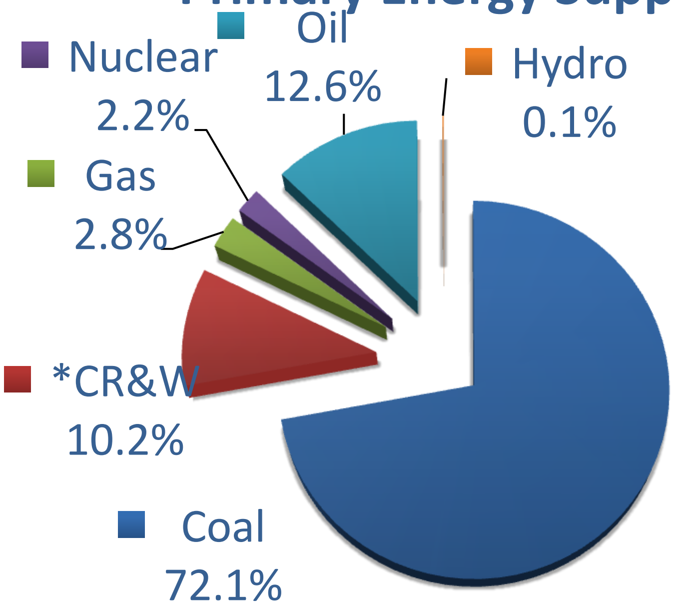
South African Energy Profile

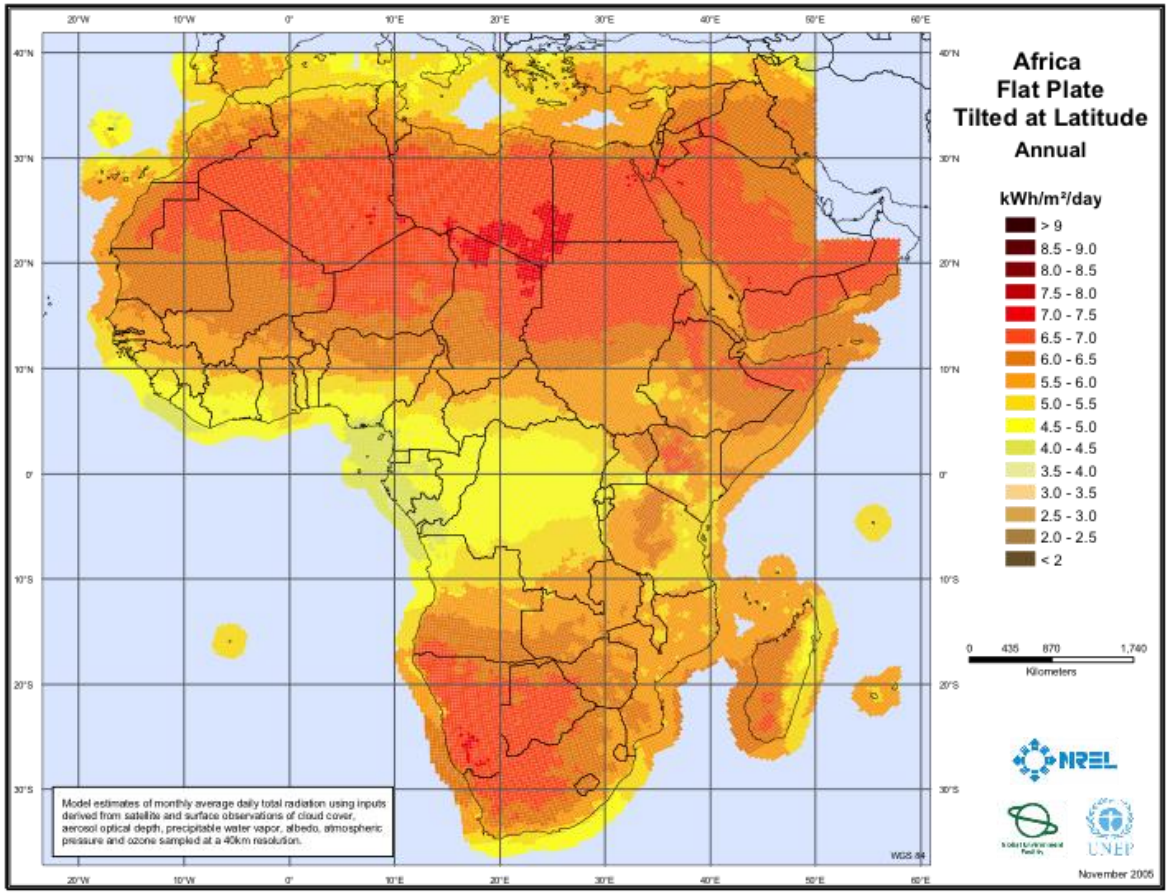
Current South Africa Total Primary Energy Supply



*CR&W: Combustible Renewable and Waste
Source: International Energy Agency (IEA)

- **Coal supplies ~75 % of South Africa's primary energy and 90 % of its electricity requirements**
- **Domestic consumption of coal amounts to ~171 million tons (~ 100 mt for electricity and ~ 70 mt for synfuels) and ~69 million tons is exported (annually)**
  - RSA has energy intensive economy
  - RSA has a large SO_2/CO_2 footprint
  - RSA's CO_2 footprint per capita ranks among the top 12 in the world
  - Large SO_2 footprint

Solar Energy Potential in South Africa



In SA:

❖AVERAGE: 4.5 – 5 kWh/m^2/day

❖1 kW/m^2 for a 5.5 hour day

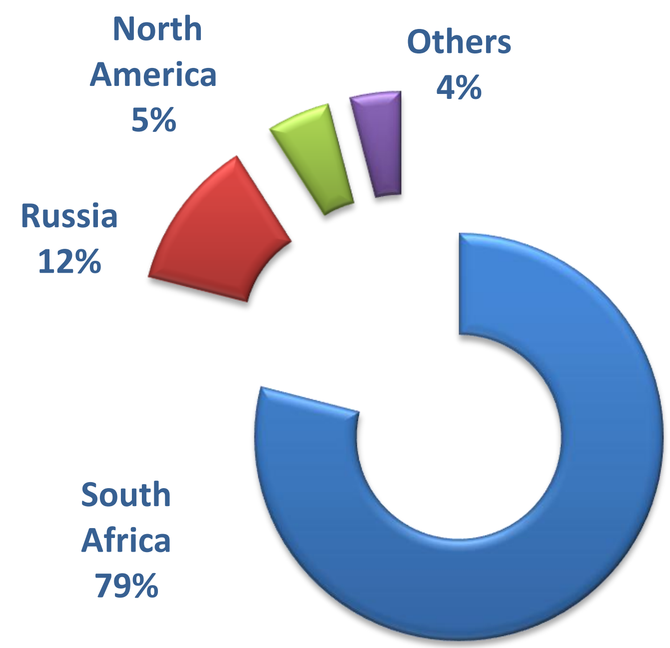
❖245 GW capacity

❖834 TWh @ 39 % capacity factor

More reading: Thomas P. Fluri – nominal capacity for CSP in South Africa is 547.6GW, Energy Policy, v 37, Issue 12, December 2009, 5075–5080

South Africa is the dominant PGM supplier

PGM Supply by region



Strategic Goals

- Develop local cost competitive hydrogen generation solution based on renewable resources
- Wealth creation through value added manufacturing of PGM catalysis, goal- supply 25% of PGM catalysts demand by 2020
- Promote equity and inclusion in the economic benefits of South Africa's resources, SMEs to play an important role

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

From: Dr Phil Mjwara, DG-DST: "Vision 2030: Hydrogen and Fuel Cells in SA", IPHE Meeting, Cape Town, 03 May 2012

PEM Electrolysers: Development strategy

Why PEM electrolysers?

1. High PGM content as platform for beneficiation.
2. PEM electrolysers are robust and dynamic: fast response to volatile renewable energy sources.
3. Can generate practical high discharge H_2 pressure.
4. Dynamic profile of H_2 production rate meeting various requirements.
5. Large-scale: addressing demand for energy storage.

Presented by the author at F-Cell, 2012, Stuttgart

PEM Electrolysers: Gen 1 high-level TDM targets (2012/13) (Gen 2 high-level targets are under review)

Category	Parameter	Unit	SOTA	Gen 1 HySA targets	Comments
Cost	H2 production costs	$/kg	0.9-10	0.9-3	1
	Capital investment	$/kg-H2 over operating life	0.6	0.3	2
Durability	Operating life	hrs	10,000-20,000	50,000 - 100,000	3
	Operating cycle	Energise/deenergise cycles	5800	>17000	4
Performance	H2 production rate	kg H2/hr		0-10	5
	Power	Kw		0-500	
	Energy efficiency (enthalpic)	%	80% at 1 A/cm2	80% at 2-3 A/cm2	6
	H2 compressed pressure	bar	15-50	250	7
Operating Conditions	Operating Cell Temparature	Deg C	50-90	60-80	8
	Operating current density	A/cm2		>3	9
	Voltage	V/cell	1.8/cell	1.65/cell	
PGM loading	Anode/Cathode total PGM loading	mg/cm2	2 to 5	0.3	10

1. Energy cost (strongly depends on electricity price in $/kWh). $/gge : gallon gasoline equivalent ~ 1 kg H2
2. Dependent on design and capacity. 3. Need to specify stationary or transient operations (e.g., linked to renewables).
4. Shut-down at least 4 times/day when system fully charged. 5. Dispensing volume in range practical for target applicati
6. Enthalpic efficiency, HHV, PGM catalysts. 7. Development of advanced seals required.
8. Membrane integrity and high T requires development.
9. Trade of with efficiency, production rate, manufacturing cost and life time. Dictate product size.
10. Trade of with costs, efficiency, durability

International Team Contribution 2012

http://www.nwu.ac.za/content/top-world-experts-attends-nwu-short-course-hydrogen-production-potchefstroom-campus-2012

Conclusions

- Fuel Cells and associated H_2 Infrastructure represent a new market which could drive growth for platinum as well as spark significant new opportunities internationally and locally in SA.

- HySA depends on Government funding so far.

- Benefits of developing H_2 infrastructure and fuel cell market in SA:

  - Means of meeting increasing demand for energy,
  - Reduction of carbon footprint,
  - Platform for mineral beneficiation,
  - Opportunity for job creation,
  - Export opportunities,
  - Increase demand for platinum group metals.

- Power-to-Gas is a new complex technology that uses renewable H2 and could become fastest growing technology utilizing electrolytic hydrogen, thus significantly increasing demand for large electrolyzes.